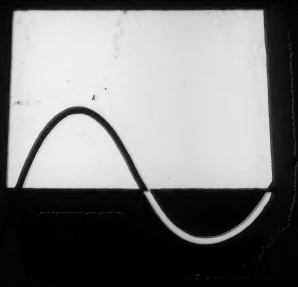
MACHINE DESIGN

August 1954



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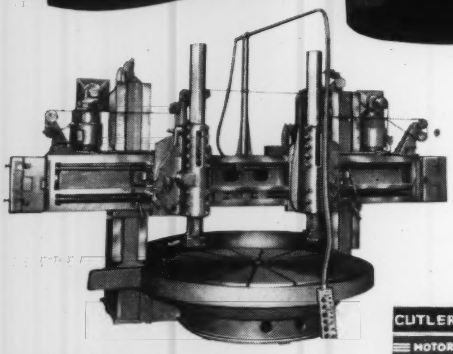

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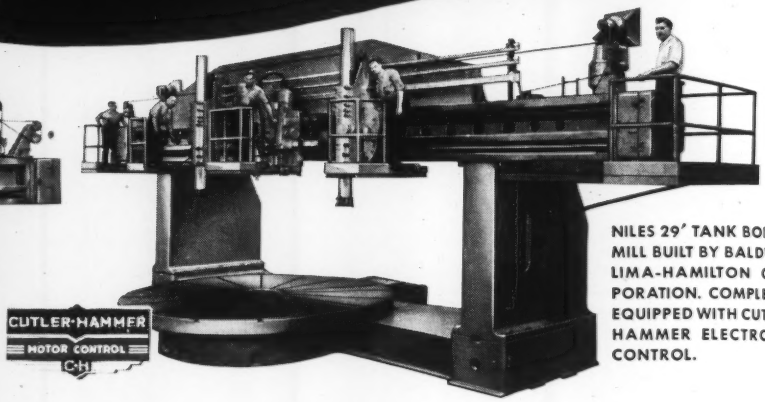

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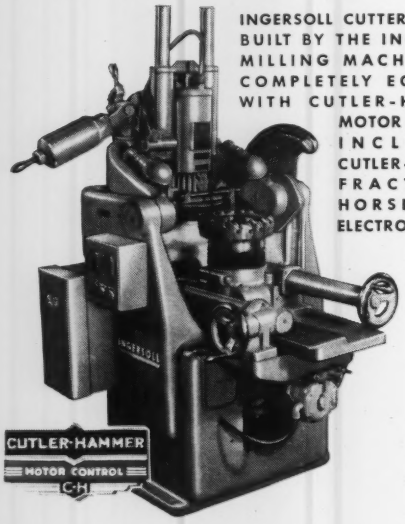

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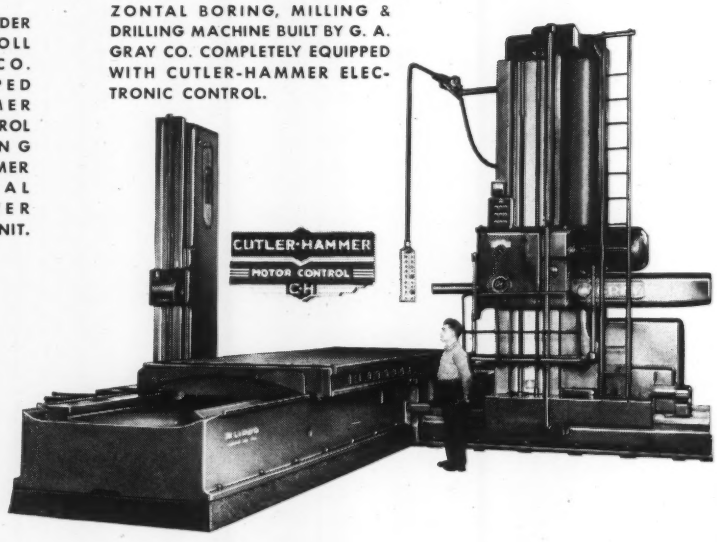

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MACHINE DESIGN

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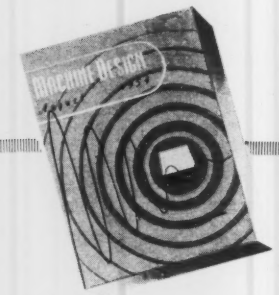
Over the Board

"High-Fashion" O-Rings

Maybe you've noticed the unusual and occasionally puzzling series of ads that Minnesota Rubber & Gasket has been running lately on O-rings (look in June MACHINE DESIGN, Page 352). Pictures of 1920 flappers kicking up their heels, sloe-eyed damsels in filmy negligees, bullfighters, deep-sea divers—and all daintily displaying an O-ring between an extended thumb and forefinger. Well, the staff got to arguing the other day whether the ads were good or bad. Didn't come to any particular conclusion, although Minnesota Rubber says that the series is really going over with a bang among engineers. What do you think of them? We'd really like to know—and we'll guarantee to pass your comments along.

This Month's Cover

If our cover this month leaves you quivering, you can blame it all on George Farnsworth, our cover artist. Epitomizing Charles Crede's article on vibration and shock isolators (Page 139) proved to be a stimulating and somewhat unnerving experience — not only for George but for the rest of the staff. Traditional method of creating a MACHINE DESIGN cover is to "try out" a half dozen or so preliminary layouts. So most of the editorial staff was reduced to a state of nervous instability by George's series of layouts — which quaked, shook, vibrated, jumped and otherwise performed peculiar visual contortions. But the final result, we think, is a rather well-engineered piece. At least, Bob Stedfeld is still cussing about the "damped decremental" vibration curve he had to lay out for George so that the cover would be technically accurate.



For Old Salts

As a change from Mickey Spillane you might find it interesting to spend some leisure reading time with Admiral Bowen's *Ships, Machinery and Mossbacks* (Princeton University Press). Those of you in any way concerned with supplying machinery and equipment to the Navy during the thirties and through the war will have heard of, or maybe even tangled with, the controversial admiral whose activities included plant seizures and operation in between successive terms of duty in such positions as chief of the old Bureau of Engineering, director of the Naval Research laboratory, and chief of the Office of Naval Research. His story has an authentic engineering flavor, particularly where he relates his series of fights with entrenched bureaucracy and conservative industry regarding high-efficiency steam machinery for warships, improved diesel engines for submarines and other craft, radar equipment and even atomic energy. The story also involves many people, some with familiar names, and the manner in which the crusty admiral got things done through people by a skillful blend of personality and authority makes a remarkable study.

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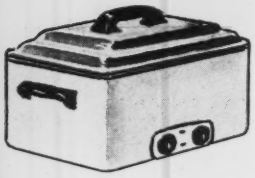
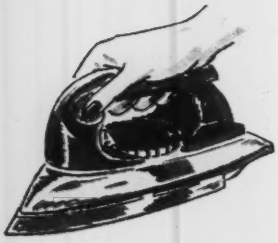


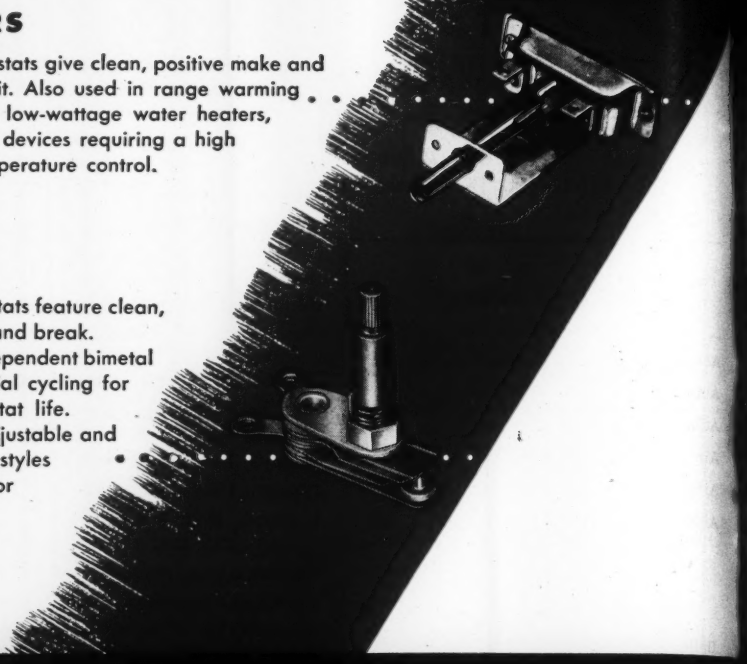
ROASTERS

TYPE R thermostats give clean, positive make and break of circuit. Also used in range warming compartments, low-wattage water heaters, and electronic devices requiring a high degree of temperature control.



IRONS

TYPE S thermostats feature clean, positive make and break. Electrically independent bimetal prevents artificial cycling for longer thermostat life. Available in adjustable and non-adjustable styles precalibrated for your product.



STEVENS thermostats make appliances perform better—longer

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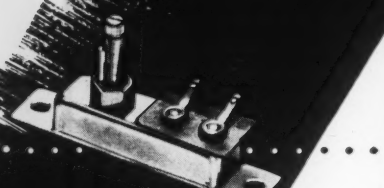

REFRIGERATORS

TYPE W thermostats give *snap-a* make or break on temperature rise. widely in butter-warming compartm electronic devices, rectifier fans, apparatus requiring sensitive, pr control of high-wattage heater l

PERCOLATORS

TYPE M thermostats have bimetal disc that gives *quick* make and break in appliance, apparatus and electronic applications where close control and compactness are essential. Open, hermetically sealed, or neoprene-protected styles for severe dampness.

Stevens makes the largest line of bimetal thermostats in the industry—several hundred styles in all. So even if you have an unusual design problem, check with Stevens first. Probably a standard Stevens thermostat will fill the bill for specifications, price and delivery—and at the same time insure the performance and life of your product. A-5517

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WITH OILGEAR FLUID POWER

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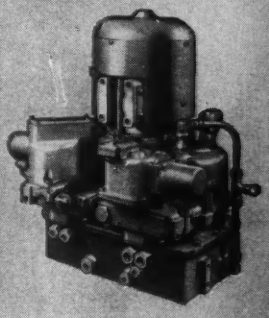
Gunners in Sherman, Pershing and Patton tanks experienced the advantages of rapid fluid power slewing and precise fluid power tracking of the turret and gun 360° in either direction. They appreciated the value of Oilgear fluid power that obeyed a light twist of the wrist. Likewise, those manning America's most effective 40 mm anti-aircraft guns, recognized the importance of automatic, self-synchronizing Oilgear fluid power drives for rapid slewing and precise tracking of the carriage 360° in either direction and the rapid, accurate elevating and depressing of the gun for quick homing on the target and following it.

Therefore, when today's new combat vehicles with far greater fire power and accuracy were planned, Oilgear ANY-SPEED Fluid Power Drives were a "Natural" for both turret traverse and gun elevation. They met the demands for accurate control over speed ranges up to 4000:1. They provided unbelievably low tracking speeds under precise response without overrun or drift. They stayed on the target for repetitive shots. No wonder, one men's magazine calls the new Oilgear equipped M47 "the sharpest shooting tank anywhere today." That's why Oilgear ANY-SPEED fluid power drives are a "Natural" on the wide variety of U. S. combat vehicles.

Don't you think it is time for you to look with wide open eyes at Oilgear Fluid Power Pumps, Motors and Transmissions for **your** machines . . . to better the performance of an already good machine? To solve a seemingly "impossible" design problem? To synchronize machine units easily and economically? To weed out trouble and cut maintenance and down time to a surprisingly low level? Counsel with an Oilgear Engineering Representative will cost you nothing, may benefit you greatly. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.



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OILGEAR

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19	60	98	222	259	295	326	TR346
20	61	99	223	260	296	327	BR346
21	62	100	L224	261	297	328	T347
22	63	101	225	262	T298	329	BL347
23	64	103	226	263	B298	330	BR347
24	65	105	227	265	299	331	TL348
25	66	106	228	267	T300	332	BL348
26	67	185	229	268	B300	333	TR348
27	68	187	230	269	301	334	BR348
28-29	69	189	231	270	T302	335	TL349
30	70	190	232	271	B302	336	BL349
31	71	193	233	272	303	337	R349
32	72	195	234-5	273	304	338	L350
33	73	197	236	274	305	L340	BL351
34	74	199	237	275	306	TR340	TR351
37	75	201	238	276	307	BR340	BR351
38	76	203	239	277	308	T341	353
39	77	204	240	278	309	BL341	356
40-41	78	205	241	279	310	BR341	IBC
42	79	206	242-3	280	311	L342	OBC
43	80-81	207	244	281			

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- For further information on New Parts and Equipment, Engineering Department Equipment, and Helpful Literature, use HELPFUL LITERATURE REQUEST CARDS—p. 191

AUGUST 1954

IFC	44	82	208	245	282	312	TR342
1	45	83	209	246	283	313	BR342
2	46-47	84	210	247	284	314	T343
5	48	85	211	248	285	315	BL343
6	49	86	L212	249	286	316	BR343
8	50	87	R212	250	287	317	TL344
9	51	88-89	213	251	288	318	BL344
11	52	90	214	252	289	319	TR344
12	53	91	215	253	290	L320	BR344
13	54-55	92	216-7	254	291	BR320	TL345
14-15	56	93	218	255	292	321	BL345
16	57	94	219	256	293	323	R345
17	58	95	220	257	T294	324	TL346
18	59	96-97	221	258	B294	325	BL346
19	60	98	222	259	295	326	TR346
20	61	99	223	260	296	327	BR346
21	62	100	L224	261	297	328	T347
22	63	101	225	262	T298	329	BL347
23	64	103	226	263	B298	330	BR347
24	65	105	227	265	299	331	TL348
25	66	106	228	267	T300	332	BL348
26	67	185	229	268	B300	333	TR348
27	68	187	230	269	301	334	BR348
28-29	69	189	231	270	T302	335	TL349
30	70	190	232	271	B302	336	BL349
31	71	193	233	272	303	337	R349
32	72	195	234-5	273	304	338	L350
33	73	197	236	274	305	L340	BL351
34	74	199	237	275	306	TR340	TR351
37	75	201	238	276	307	BR340	BR351
38	76	203	239	277	308	T341	353
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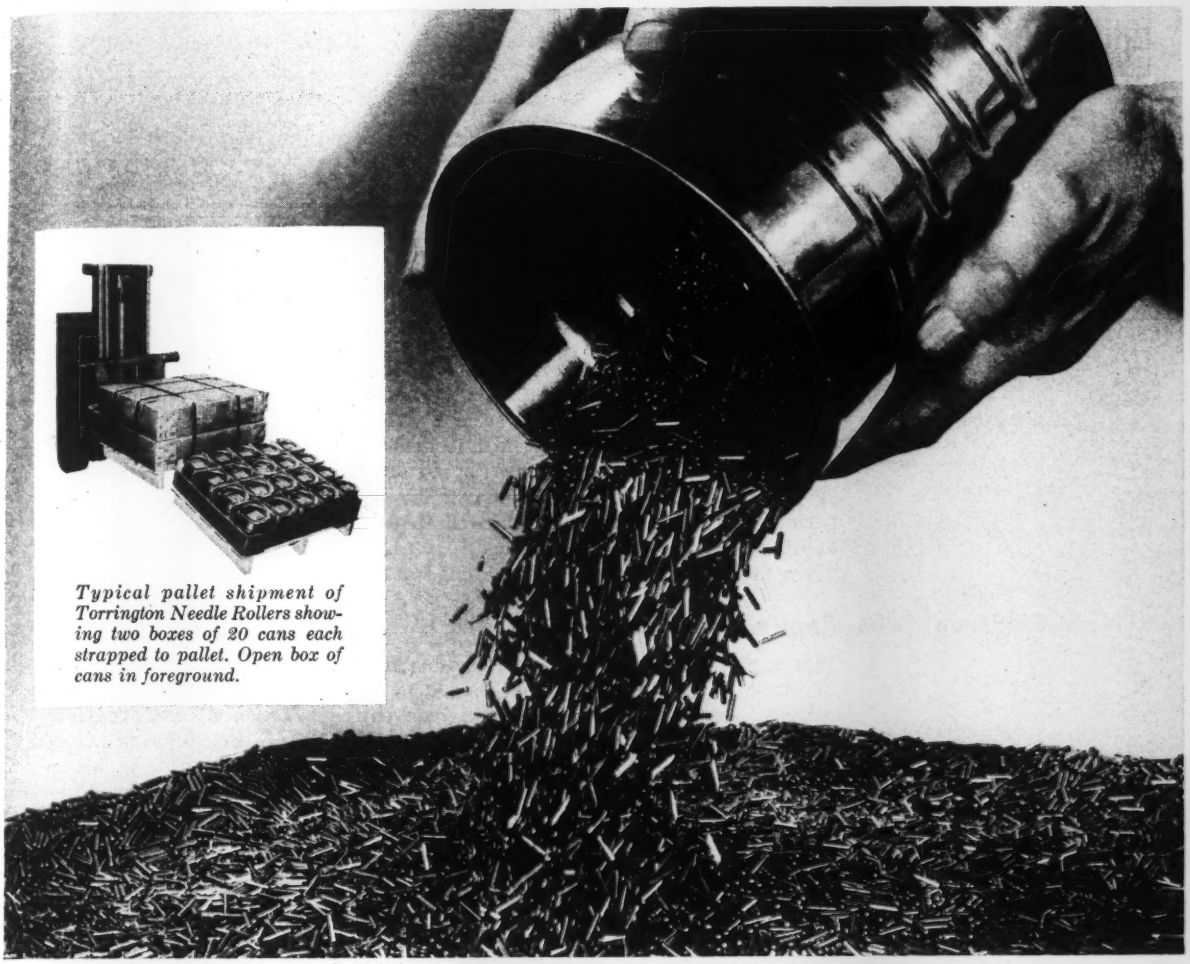

Typical pallet shipment of Torrington Needle Rollers showing two boxes of 20 cans each strapped to pallet. Open box of cans in foreground.

Torrington Needle Rollers—Vacuum-Packed for Cleanliness—Palletized for Easy Handling

Torrington Needle Rollers by the millions are now being vacuum-packed in tin cans to protect them from dirt, moisture and damage. The foods you eat are not packed with greater care.

This new vacuum pack permits us to send you rollers *dry*—free from oil or grease—so that they can go into your loading machines direct from the can, without time-consuming degreasing.

To make shipping and handling easier, we pack these cans 20 to a carton and strap two cartons to an expendable wooden pallet, for a total weight of about 1500 lbs. per pallet. This makes an easy load for your fork lift trucks to handle and store.

Torrington Needle Rollers deserve this special vacuum pack. They're precision rollers made under statistical quality controls of extraordinary rigor. Every step from alloy selection to polishing and packing is carefully checked to assure you that every can of rollers you receive meets your high standards. And to help you use these rollers to best advantage, Torrington's engineering staff is always available to assist in application design and testing.

Always specify Torrington for precision Needle Rollers in prime condition. In stock for immediate volume shipment.

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TORRINGTON NEEDLE BEARINGS

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MACHINE DESIGN

Topics ...IN ENGINEERING AND RESEARCH

Painless Dentistry May Be Here

Two recently announced dental drills give promise of making honest men of those advertising painless dentistry. One of the drills, evolved by dental experts of Britain's Royal Air Force, uses ultrasonic vibration at a frequency of 25,000 cycles per second. This frequency is also said to be ultra-feelic, since hardly any heat is generated by friction. A hand-held hydraulic turbine which attains a speed of 61,000 rpm has been developed at the National Bureau of Standards for the same purpose. High speed permits low cutting pressure, thus eliminating pain. Even when operating at 61,000 rpm, it is said that the turbine can be safely stopped by placing a finger abruptly against the edge of the cutting tool.

New Electron Tube Really Stacked

Plates, grids, filaments and other components of a new kind of electron tube developed by Sylvania Electric Products Inc. are stacked one upon another in assembly as opposed to the conventional concentric arrangement. Developed under contract with the U.S. Navy Bureau of Ships, the new tubes are said to lend themselves to mass production in addition to being better, more reliable performers. Ceramic envelopes used, instead of the conventional glass bulb, are said to permit dropping without breakage and resist thermal shock and high temperatures.

Engineered Marriages Long Lasting

Findings of a recent survey conducted by the Illinois Institute of Technology are that engineers stay married. Although 25 per cent of U. S. marriages end in divorce, reports from 1500 members of the IIT classes of '29, '34, '39, '44 and '49 showed only one divorce for the class of '29 and a divorce rate of 2 per cent for the class of '34. No divorces were reported in the '39, '44 and '49 classes although 90 per cent of the members of these classes are married. An IIT spokesman suggested that the reason may be the relatively high security level enjoyed by engineers.

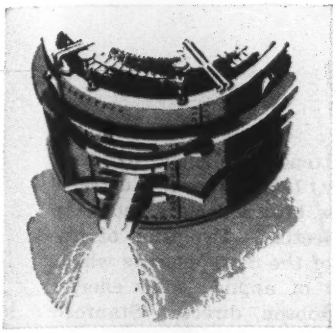
Atom Age Arrives (Well Almost)

Although the five cent cigar is departed, a one-dollar Geiger counter has arrived to help usher in the atomic age. About the size of a pocket knife, the device will detect and measure the activity of alpha rays, the deadliest emissions produced by atomic fission or fusion. Developed by Wallace L. Minto, chemist and ex-AEC researcher, the 1-ounce Geigerscope will be produced by Ken Research Inc. The scope looks like a tiny telescope and is held to the eye for inspection of a suspected specimen. A screen in the scope converts the energy of alpha rays into visible light where it is bombarded. Flashes can be counted to determine extent of radioactivity. Each scope comes with an ore sample containing about ten per cent uramium oxide.

Solar Energy Association to Meet

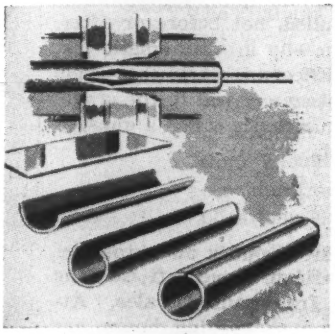
Machine designers may be able to get in on the ground floor of a new industry by attending the World Symposium on Applied Solar Energy to be held at Westward Ho Hotel in Phoenix, January 12-15, 1955 under the leadership of Stanford Research Institute. Sponsored by the Association for Applied Solar Energy formed last March 17 by a group of

7 REASONS WHY Ostuco Single Source Service Saves You Money!

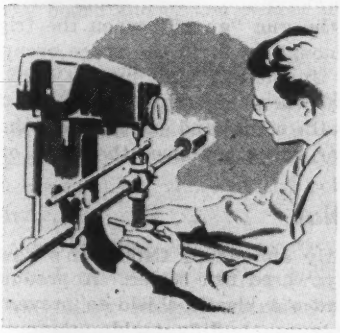


1. OUR OWN STEEL SOURCE. *As a member of the Copperweld family, Ostuco controls its own steel supply . . . your assurance of prompt deliveries.*

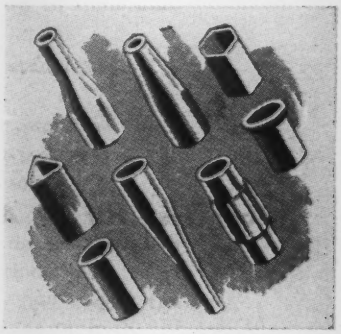
Wherever you use tubing in any form . . . or wherever the advantages of tubing will make your product more competitive . . . Ostuco's *single source service* can save you money. One purchase order takes care of all details. Every manufacturing step from raw materials to finished product is carefully controlled and quality-checked. Your production schedules are rigidly maintained. Other advantages of Ostuco's *single source service* are outlined in an informative booklet, "Ostuco Tubing," yours for the asking. Or better still—for conclusive proof—send us your blueprints for prompt quotation.



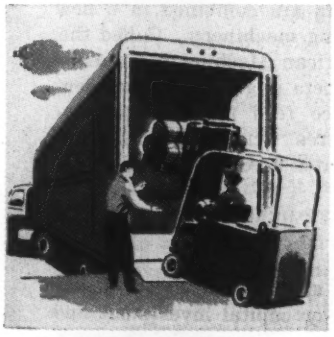
2. SEAMLESS AND WELDED TUBING. *As manufacturers of both seamless and electric welded steel tubing, Ostuco's facilities are flexible to meet your needs.*



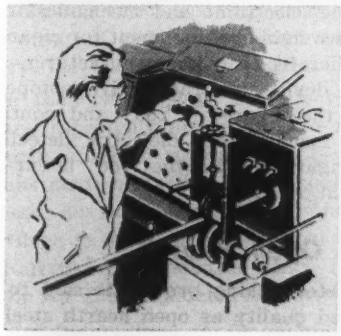
3. VARIOUS ANALYSES. *Ostuco offers carbon and alloy steels which meet all ASM, AMS, ASTM, AISI, and Federal specifications.*



4. FABRICATING AND FORGING. *Under one roof, Ostuco's modern equipment and skilled craftsmen provide uninterrupted manufacturing, fabricating, and forging service.*



5. SPECIALTY ITEMS. *Ostuco is especially geared to handle smaller production quantities with the same economy normally possible only in larger runs.*



6. QUALITY CONTROL. *Rigid inspection and precision tests at various stages of manufacture assure homogeneous quality and uniformity.*

7. CONSULTANT SERVICE. *The diversified knowledge and experience of Ostuco's engineering and design departments is always at your service.*

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SEAMLESS AND ELECTRIC WELDED STEEL TUBING —Fabricating and Forging

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CANADA, RAILWAY & POWER CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
117 Liberty Street, New York 6, New York

Southwesterners, the four-day meeting will be attended by solar engineers and scientists from England, France, Germany, India, Japan, Australia and South Africa. Design of sun-operated pumps, heat collectors and solar stills will be discussed at one session of the meeting. Evolution of the heat pump in the last ten years is one example of the developments which make the engineering and economic feasibility of applied solar energy look very promising, according to Dr. J. E. Hobson, director, Stanford Research Institute.

TV Gun is Not Real Pistol

A small radio transmitter using a transistor has solved TV's problem of having the gun "go off" when the trigger is pulled, not before or after. Small enough to fit in the space occupied by the clip in a automatic pistol, the transmitter built by the NBC Special Effects Department, sends its signal when the trigger is pulled. A loop antenna, taped to the stage, receives the signal and energizes another electronic device called a gunshot generator which produces the noise of the shot.

Poor Fish Hit by Automation

A recently announced fisherman's power tool kit includes an automatic, electric-powered fish scaler. A product of American Homecraft Co., the kit includes a plastic shield to prevent injuries from sailing scales. Attachments for buffing tackle, cleaning reels and sharpening hooks are also included in the kit. Poor fish!

Atoms Weigh Cigarettes

Nucleonic, electronic and mechanical components are combined in a new cigarette-weighing attachment for cigarette-making machinery. Called the AMF Microfeed by its manufacturer, the American Machine & Foundry Co., the device uses radioactive isotopes and a beta gage to measure density of the cigarette "rod" and control tobacco feed to the cigarette-making machine. A dielectric detector measures weight of each individual cigarette after the "rod" is cut and actuates a rejector to kick out off-weight cigarettes.

New Steel Process Equals Open Hearth

A new steelmaking process is said to produce steel of the same closely controlled quality as open hearth steel with lower capital investment and lower operating costs than the open-hearth process. Essentially, the process consists of blowing a jet of high-purity oxygen upon the surface of a molten pig-iron bath in a converter vessel. Brassert Oxygen Technic A. G. of Switzerland developed the process; sole United States licensor is Kaiser Engineers Div., Henry J. Kaiser Co.

Atoms Aid Plastics Molding Producers

In what is believed to be the first peacetime application of atomic energy in the plastics molding industry, radioactive tracer techniques have been used to produce an improved thermosetting molding compound. Radioactive sprue bushings were used by General Electric Co.'s Phenolic Engineering Lab to determine the amount of erosion in molds caused by plastics molding compounds. Results of the program have enabled formulation of molding compounds with markedly reduced mold erosion rates.

MACHINE DESIGN

AUGUST 1954

A Lesson from Oppenheimer

THE IMPORT of the Oppenheimer case will not be lost on the many engineers in government or engaged on projects which come under security regulations. The findings of the Gray board and of the A.E.C. itself add up to something like this:

> No one cleared for security can be allowed to set his own standards of care and vigilance in observing security regulations.
>
> A scientist or engineer hired for his scientific or engineering qualifications should base any advice or recommendations strictly on technical considerations, not on his personal views of the political or social implications of that advice.

In other words, stick to your knitting, let the security experts decide the rules on security and let the political experts decide the political questions.

Dr. Oppenheimer and his fellow nuclear scientists profess to feel keenly the terrible impact that their work has had on the world. They would like to influence the conduct of national and international affairs toward a permanent peace that would forever eliminate the use of an H-bomb or another A-bomb.

But that influence will not be attained either by joining peace-front organizations or by letting political thinking affect scientific decisions. The political machinery whereby any citizen or group of citizens can exert influence is already at hand and has been, in our country, for nearly two centuries.

Engineers, too, because their work plays such a vital part in the development of our civilization, are repeatedly urged to take a more active interest in determining how the products of their efforts shall be used for the benefit of mankind. But it is not always made clear that they should do so as citizens rather than as engineers. Engineers, as such, even if they hold engineering positions in government, have no privilege to speak up on political matters. As citizens, however, they can work toward elective or appointive office in national, state or local government for themselves or for the candidates of their choice and thereby merit attention to their views.

The sane and practical voice of the engineer is badly needed at all levels of government. But there is no shortcut to the hard and often devious political way that our distinguished fellow engineer, Senator Flanders, has successfully followed. On the other hand, Dr. Oppenheimer has done us a service by demonstrating how *not* to win friends and influence people.

Colin Carmichael

EDITOR

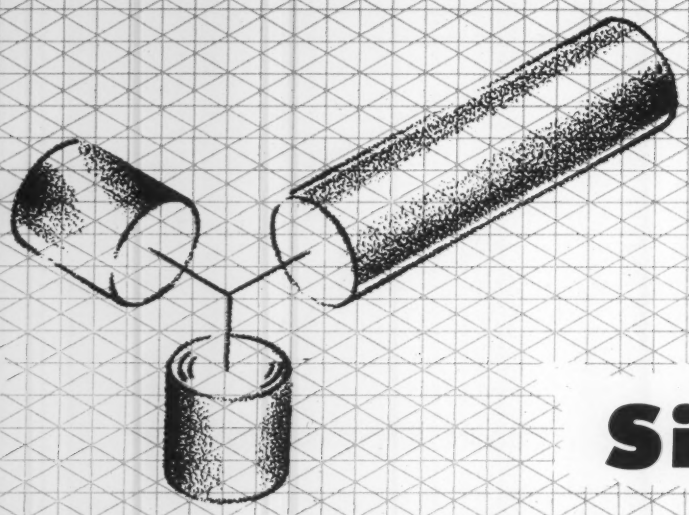


Fig. 1—Standard isometric paper makes possible quick, fairly accurate sketches

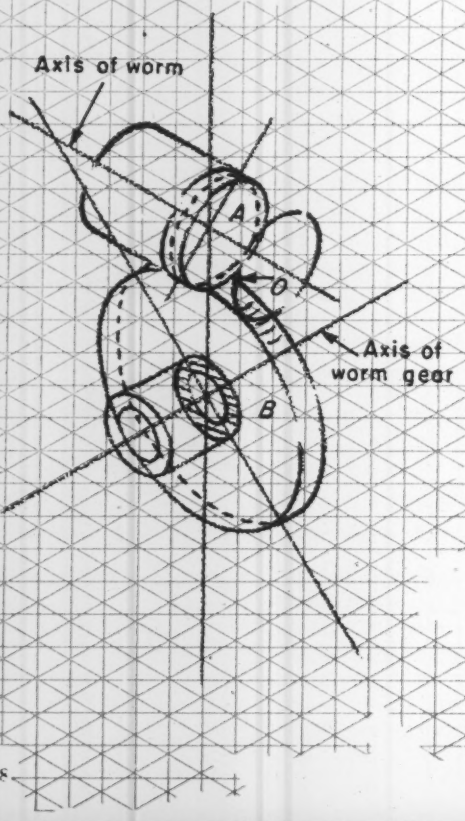
Simulated Perspective Sketching

. . . a design tool for selling ideas quickly and easily

By Peter F. Kranz

Control Engineering, Motor and Control Div.
Westinghouse Electric Corp.
Buffalo, N. Y.

Fig. 2—Beginnings of a sketch of a gear reducer using isometric paper



PERHAPS the biggest single factor in a design engineer's success is his ability to communicate his ideas quickly and understandably. And the difficulty of so doing increases directly as the complexity of his work.

Standard drawing techniques, including projected pictures and detailed drawings, are eminently satisfactory to transfer ideas to shop personnel. Similarly, when working with other members of the design department—draftsmen, technical representatives or other engineers—simple sketches coupled with a rather large amount of oral communication usually provide a perfectly satisfactory method of transmitting ideas.

However, standard sketches used by an engineer when talking with draftsmen are not always satis-

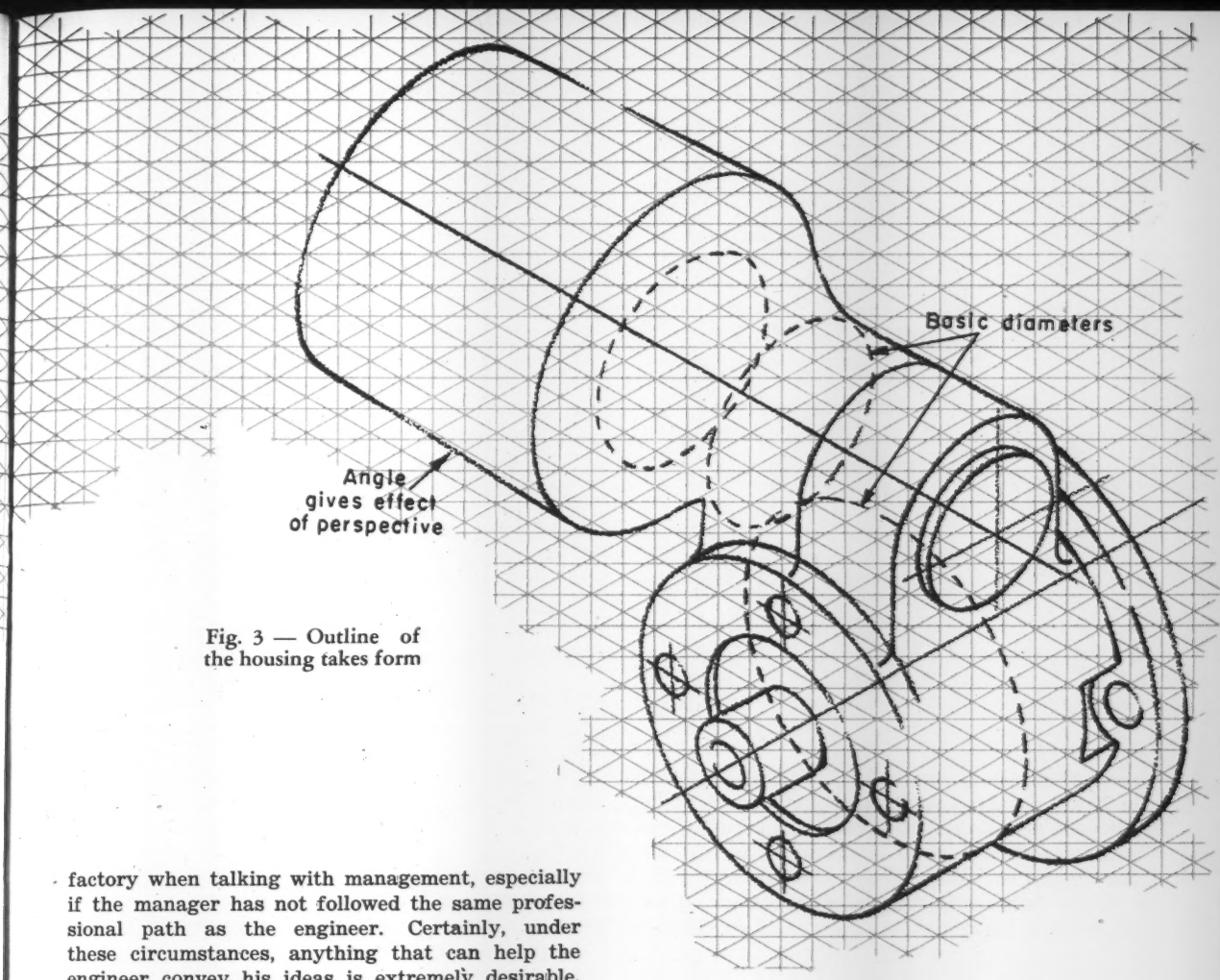


Fig. 3 — Outline of the housing takes form

factory when talking with management, especially if the manager has not followed the same professional path as the engineer. Certainly, under these circumstances, anything that can help the engineer convey his ideas is extremely desirable. A picture is the answer

Simple perspective sketches can be of inestimable assistance in solving this communication problem. Obviously, such sketches should not be thought of as a panacea that will make any presentation successful. On the other hand, an idea that might be discarded for want of adequate presentation often can be rescued with sketches.

Most will grant that the use of perspective sketches is a good idea, except that they feel that the time required to draw them is not warranted, especially when the investment in the usual sketching time is weighed against the results. Much of this feeling stems from the belief that either great time or true artistic ability is required to make a presentable sketch. While artistic ability would be helpful, this article is directed at the engineer who neither is, nor attempts to be, a painter, sculptor, or illustrator of any sort.

Perhaps the first thing to clarify is the use of the word "perspective." True perspective employs so-called "vanishing points" which make a drawing more difficult to construct. However, for many machinisms and small machines there is little necessity to use vanishing points. In such sketches, simple "isometric" drawings are frequently adequate to convey the idea and give a real sense of depth. They have the additional advantage of being much easier to make, and in most cases fill the purpose.

Mechanics of "Perspective" Sketching: Isometric drawings can be made on tracing paper without guide lines of any sort; however, most people will find it easier to use standard isometric paper such as shown in *Fig.* 1. Three cylinders are shown, each at right angles to the other. The grid of lines dividing the isometric paper into equilateral triangles serves as a guide for sketches. Each group of parallel lines may be thought of as a group of parallel wires, and each group of wires, like the cylinders, at right angles to each other. These lines can be of great assistance in determining the proper relationship of different parts of the sketch.

Simple though it is, *Fig.* 1 contains all the elements of an isometric drawing. The ends of the cylinders appear as ellipses, with the axis of the ellipse changing from one cylinder to the next. One way to visualize this is to imagine each cylinder laid flat upon a table, arranged to form a "Y". In this position, the ends will not be visible from a point directly above the center of this "Y". Now, if each cylinder is rotated until its axis is

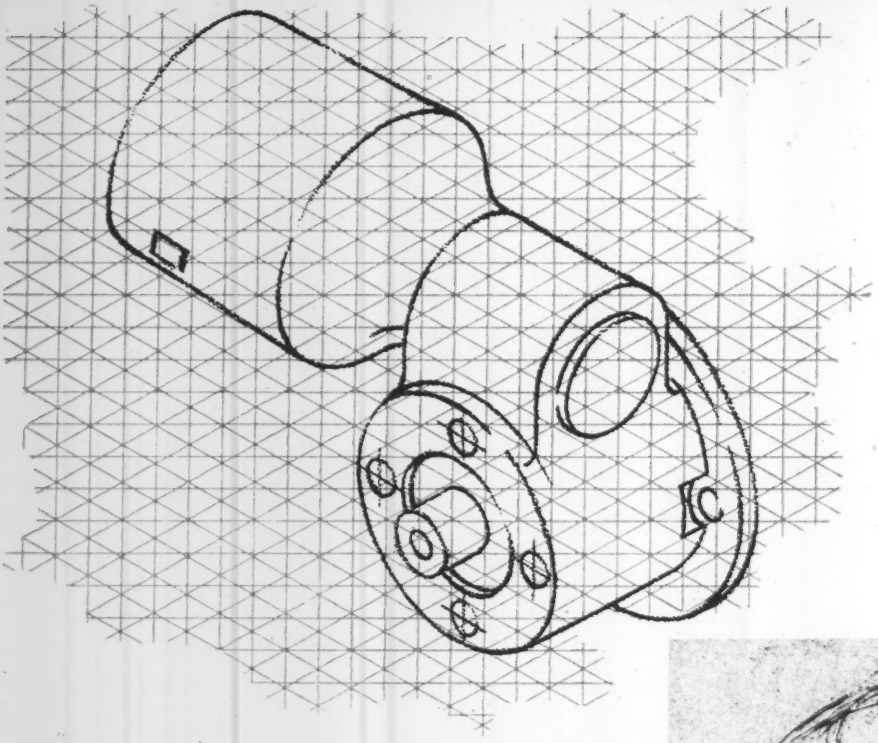


Fig. 4 — Left — Pencil sketch simplified to show only major outlines

Fig. 5—Below — Drawing by Da Vinci illustrates classical method of shading

at right angles to the other two, the configuration in *Fig.* 1 is obtained. Notice that the profiles of the ends of the cylinders started as straight lines, each of which is at an angle of 60 degrees with the other two. And as the cylinders are rotated, the lines bulge in the middle, then become ellipses. In isometric drawing each axis is inclined at the same angle to the observer so that all of the cylinders use the same ellipse. The only difference is the orientation of the axis of the ellipse. One or more ellipse templates can be extremely useful in making complete drawings. The smaller guides are quite inexpensive, as *Table* 1 indicates, and since most circles normally used are small and can be drawn with an inexpensive guide, this should be the first piece of equipment to be considered.

Note that the upper right-hand cylinder appears appreciably larger at the far end, caused by the lack of perspective. This error is more noticeable in long objects. However, as shown later, a simple correction can frequently be applied.

Probably the best way to demonstrate the simplicity of the isometric sketching technique is to follow the construction of a typical sketch of a special gearmotor. The sketch will show: (1) a worm and worm gear with certain fixed diameters; (2) a worm gear with a hollow shaft; (3) a reducer mounted against a panel and having a secondary mounting face parallel to the first at its other end; (4) a worm-driving motor that is integral with the reducer.

Beginning of such a sketch is shown in *Fig.* 2. On the drawing papers listed in *Table* 2, these guide lines are printed in a soft contrasting color, and do not conflict with the sketch.

Start of the sketch is by far the most important. At this time the spatial relationships of all the parts of the sketch are determined. Apply this thinking to the sketch of the reducer, and you have the following procedure:

1. Draw to an appropriate scale the pitch line of the worm, using a small ellipse template. Be careful to align the axis correctly.
2. Pitch circle of the worm, *A*, and the worm gear, *B*, are tangent at a single point, *O*. Since the gear ratio is fixed, choose an ellipse for the worm gear that has the proper ratio to the first one drawn. Move the template up the line *AB* until the two pitch lines touch at *O*, and draw a circle.

3. Having drawn the pitch circles, locations of the worm axis and the worm-gear axis are now determined and can be drawn.
4. Now extend the pitch circles to the ends of the gears and draw in the major diameters.
5. Complete the first section by drawing in part of the hollow worm gear shaft.

Next, put a housing around the gears. Presumably, *Fig.* 2 has been drawn lightly in pencil and will serve as a guide for the housing. In *Fig.* 3, however, the lines that would normally carry over from *Fig.* 2 have been omitted for clarity. In other words, *Fig.* 3 represents only new lines drawn to indicate the housing.

Since the worm gear is large in diameter, it will determine the major dimensions of the gear case. Sketch in some rough circles that would enclose the gears, as shown by the dashed lines. In the sketch the special gear case has a mounting face on the near side and mounts on some support on the far side. Having determined the major dimensions, extend the basic diameters to form the completed case. At this point, you have a group of ellipses drawn apparently at random, but by conjuring up a mental image of the reducer, one can see that portions of the ellipses should be darkened and some connecting lines drawn. Once done, presto! a reducer—or at least a part of one.

Adding the motor completes the design, so two ellipses are drawn to indicate the extremes of the motor shell. If these ellipses are connected with lines to outline the motor, then the motor appears tapered. As mentioned earlier, this is due to the lack of perspective. Certainly, the simple solution at this point is to introduce some slight persepective by drawing a smaller ellipse at the far end and completing the motor outline. A little trial and error will usually produce a satisfactory appearance.

By now the sketch has become a little cluttered where actually order and simplicity is what is wanted. Methods for bringing order will vary, but tracing the important outlines with a fountain pen, meanwhile erasing all the unnecessary detail,

Table 1—Templates

Supplier	Small Ellipse Templates: Description	Thickness (inches)	Approximate Cost* (dollars)	Large Ellipse Templates: Description	Thickness (inches)	Approximate Cost* (dollars)	Special
Dietzgen Co. 2425 Sheffield Ave. Chicago 14, Ill.	No. 2271; isometric; 1/8 to 2 inches in 27 steps; 6 by 9 inches	0.030	2.75	No. 2271L; 8 3/4 by 19 1/2	0.020	3.25	
Keuffel & Esser Co. Adams & Third St. Hoboken, N. J.	No. 1314–10; isometric; 1/8 to 2 inches in 19 steps	0.020	3.60	No. 1314–20; isometric; 2 1/8 to 5 inches in 8 steps; half circles	0.020	3.85	
A. Lietz Co. 520 Montgomery St. San Francisco, Calif.	No. 3233; isometric; 1/8 to 2 inches in 27 steps	0.020	3.15	No. 3232; isometric; 2 to 4 inches in 12 steps	0.020	3.75	
Rapidesign Inc. P. O. Box 592 Glendale, Calif.	No. 123; isometric; 1/8 to 1 1/8 inches in 38 steps; milled ellipses	0.040	3.00	No. 124; isometric; 1 1/2 to 7 inches in 25 steps; milled bevel edges; half circles	0.080	5.00	No. 121; hexangle template for bolts and nuts; 3/8 to 3/4 hexangle in 6 steps at 6 different projections; $4.00; 0.030-inch
	No. 401; 30-deg projection; 3/8 to 2 3/4 inches in 17 steps		2.00				
Timely Products Co. P. O. Box 416 Basil, O.	No. 90; 30 deg, 45 deg, 60 deg, 75 deg; 3/16 to 1 inch in 10 steps	0.030	2.00				No. 40; tilt hexangle for bolts and nuts; 3/8 to 3/4 hexangle in 6 steps at 5 different projections; $1.50

* April, 1954.

Table 2—Isometric Paper
(8½ by 11 inches)

Supplier	Number	Color	Do Lines Print?	Rectangular Lines Superimposed?	Some Lines Accented?	Spacing Between Diagonals (inches)	Minimum Order (sheets)	Approximate Cost per Sheet* (cents)
Charles Bruning Co. Inc. Teterboro, N. J.	700–1 M	Orange	Yes	Yes	No	3/16	10	4.5
Clearprint Paper Co. 1482-67th Street Emeryville, Calif.	T–325	Brown	Yes	Yes	No	3/16	1	5
		Brown	No	No	No	1/8	1	5
Dietzgen Co. 2425 Sheffield Ave. Chicago 14, Ill.	340–1	Green	Yes	Yes	No	3/16	12	4.2
Keuffel & Esser Co. Adams & Third Sts. Brooklyn 17, N. Y.	359–29B	Blue	No	No	Yes	7/32	10	5
	359–30	Orange	Yes	Yes	Yes	7/32	10	5
Ogilvie Press, Inc. 691 Fulton St. Brooklyn 17, N. Y.	150–24P	Blue	No	No	Yes	1/8	50	3.3
	150–24G	Green	Yes	No	Yes	1/8	50	3.3
	150–25P	Blue	No	Yes	Yes	1/8	50	3.3
	150–25G	Green	Yes	Yes	Yes	1/8	50	3.3

* April, 1954.

Fig. 6—Method of varying light within the plane to achieve the shading technique

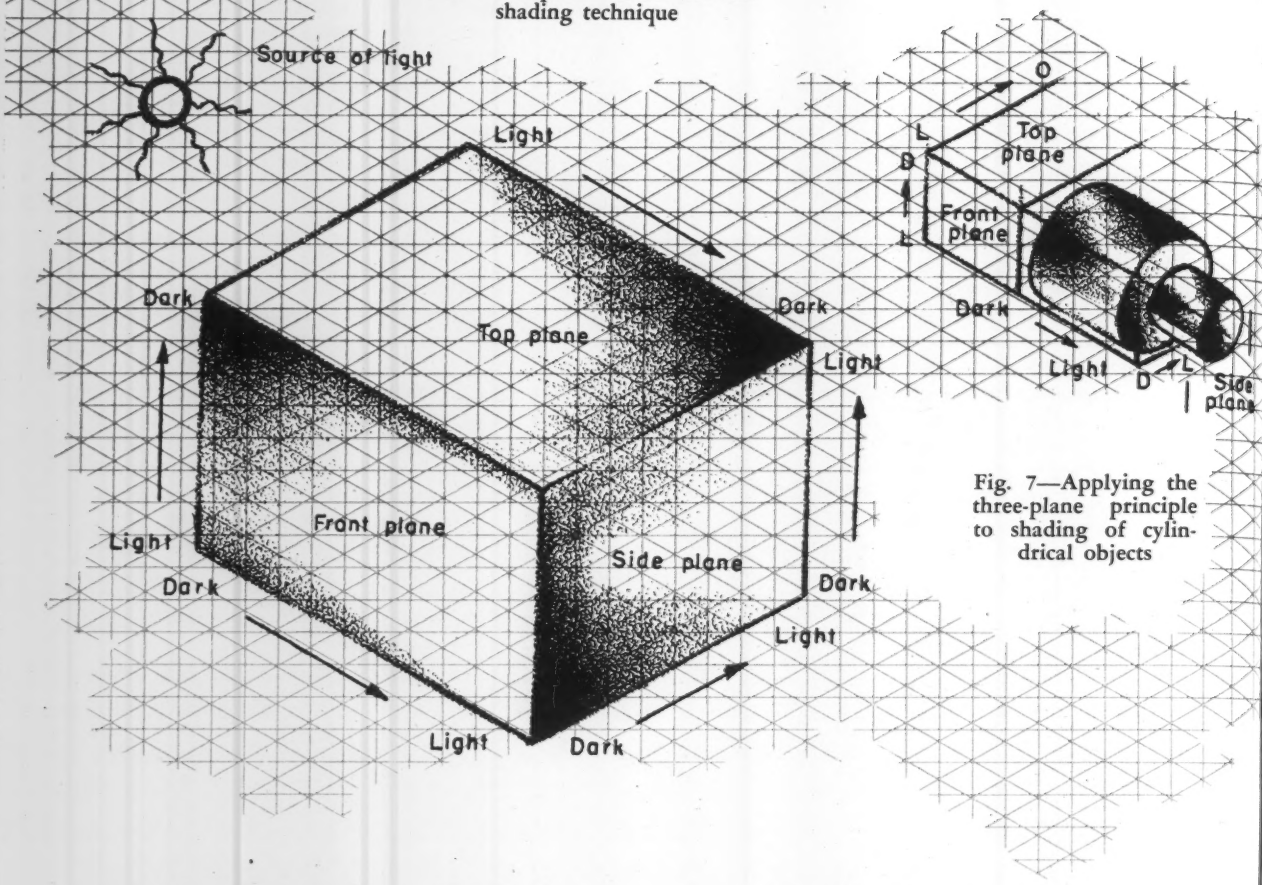


Fig. 7—Applying the three-plane principle to shading of cylindrical objects

is usually sufficient, *Fig.* 4 To save time, the curves can be drawn free-hand, following the pencil ellipses made with a template. If more exact work is desired, a ruling pen can be used. On the other hand, the use of pencil throughout is often satisfactory.

Shading the Drawing: Any of many shading techniques may prove satisfactory, but for the beginner it is perhaps best to start with a classical method that was developed during the early Renaissance, and from which a certain stylized representation has emerged. This technique, while frequently not photographically accurate, looks accurate simply because it is commonly used. *Fig.* 5 shows a drawing of a girl's head by Leonardo da Vinci that illustrates this principle of shading.

The method Leonardo employs in rendering form may be described as light falling on three planes—a front, side and top. In *Fig.* 5, the light falls on the head from the upper left hand corner, with most of the light reflected by the top of the head, the upper eyelids, the tip of the nose, the lower lip, the cheekbones and chin. For simplicity these elements may be called the top planes. The triangular area of the face including the forehead, eyes, nose, mouth and the lower part of the chin may be called the front plane, while the heavily shadowed area is the side plane.

Since the light source comes from the upper left, the top planes reflect the most light, the front planes second, and the side plane least.

This can be visualized better by referring to *Fig.* 6, a simple block illuminated by a similiarly located light source. Each break in plane is emphasized by an abrupt transition from light to dark, the greater the break in plane, the greater the contrast. This accentuation of a break in plane by increasing or diminishing the apparent light reflected was the Renaissance method of rendering form.

Two basic methods are used to accomplish this classical technique. The first is discussed above. The second involves a variation in reflected light within the plane itself, *Fig.* 6. In this case, the light variation proceeeds from dark to light in two directions across each plane. In some abstract drawing each section of a plane might be differentiated thus, so that by reading the reflected light with an accurate photoelectric device, exact location of a point could be determined without a ruler. This, certainly, is the hard way of determining locations exactly, but it does point up why the

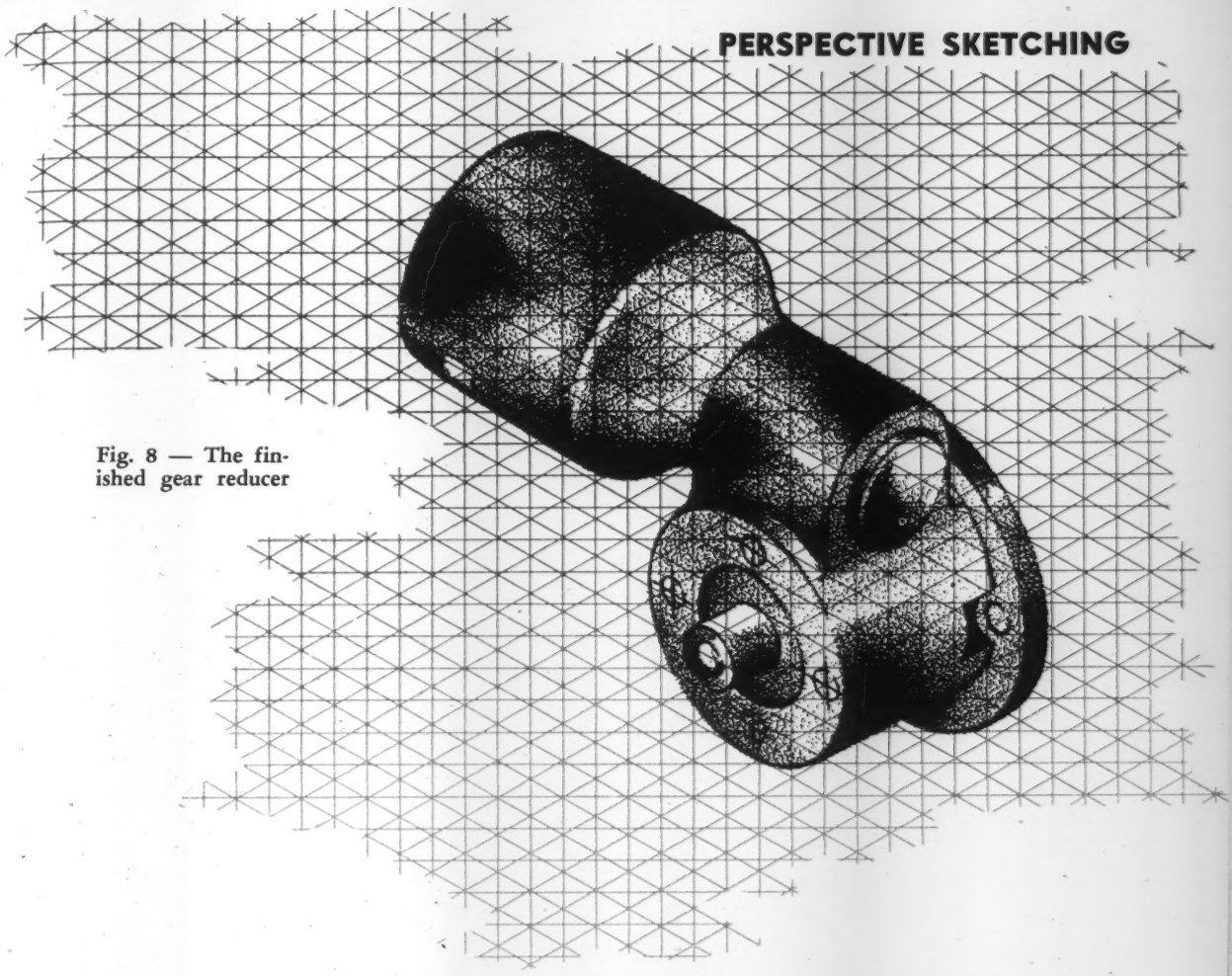


Fig. 8 — The finished gear reducer

shading technique is valuable. The eye places each point in its proper location, largely aided by the shading of adjacent areas.

Thus the solution to the shading problem can be divided into three phases: (1) shade each plane in two directions; (2) shade the three planes in three hues, light for top, medium for front, and dark for side; (3) arrange these two techniques to give the greatest contrast at the change in plane. The rectangular solid in *Fig.* 6 is shaded to show typical results.

Actually, the resulting shadows are not what would be expected in a photograph. For example, the front plane is darkest toward the light source. The Renaissance logicians brought forward the concept of "reflected light" from the back side to explain this discrepancy. But the merits of the technique are not of primary concern, for the basic concept of showing the change in plane by a contrast in shading is a successful solution to a difficult problem.

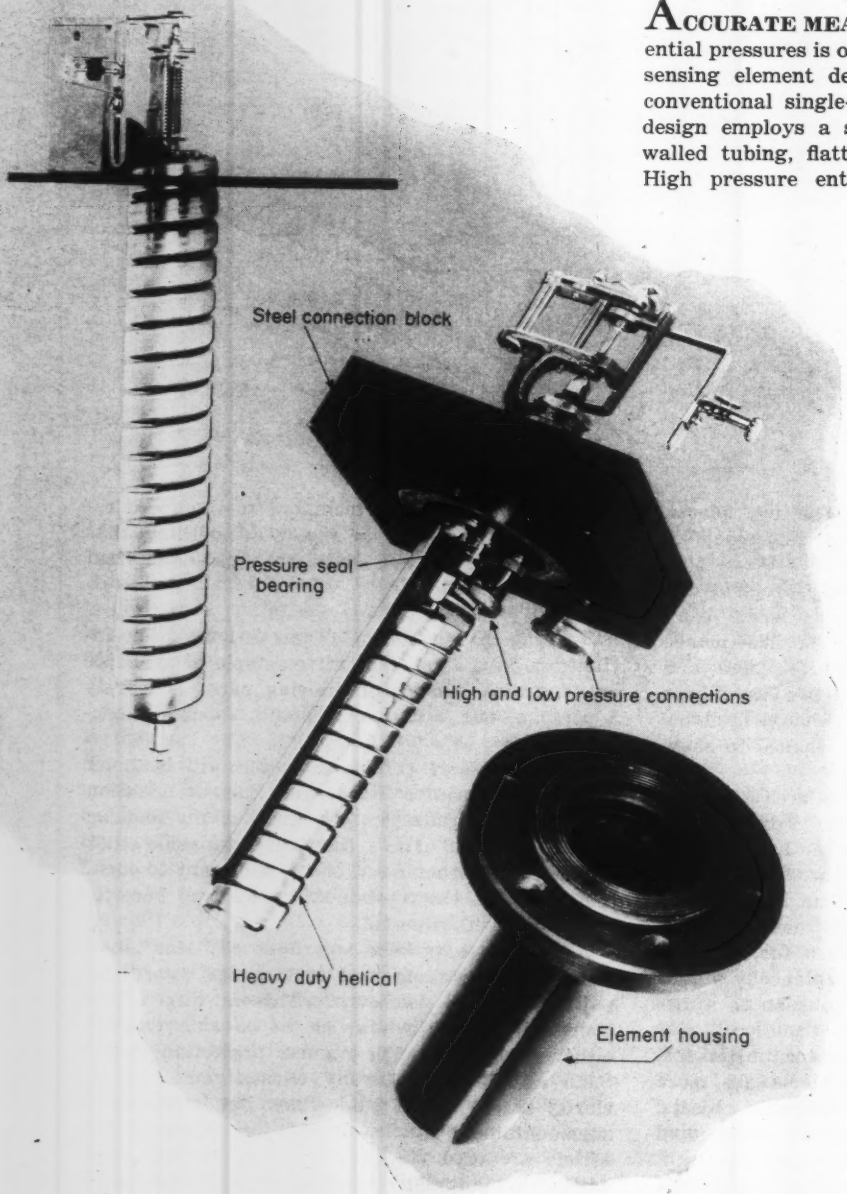
The perspicacious reader may now object for, after all, the usual shading problems are more complex than those of mere rectangular objects. For instance, how can a cylinder be represented by three planes? The answer is simplicity itself. Pretend the cylinder has three planes, as shown in *Fig.* 7. Now apply this technique to the speed reducer, and the result is *Fig.* 8—something that can be completed in a short time once the final form has crystallized.

Drawing Aids: *Tables* 1 and 2 have been included to give a representative sample of available drawing aids. Choice of drawing paper is largely a personal one, but several points should be considered.

Do lines print? A simple sketch will be much clearer when printed if the guide lines do not show in the final reproduction. For most of the sketches discussed in this article, this is the desirable situation. On the other hand, some will want to make alterations on the reproduced copies, and here the guide lines will be useful.

Are rectangular lines superimposed? Many manufacturers have combined rectangular co-ordinate paper with the isometric. This is directed, of course, at people who wish to be able to draw either a perspective or regular projection sketch. Such a solution naturally causes some lack of clarity in the use of guide lines, but is not an insurmountable obstacle. If the techniques of this article are used frequently, the specialized paper without rectangular co-ordinates may be preferred.

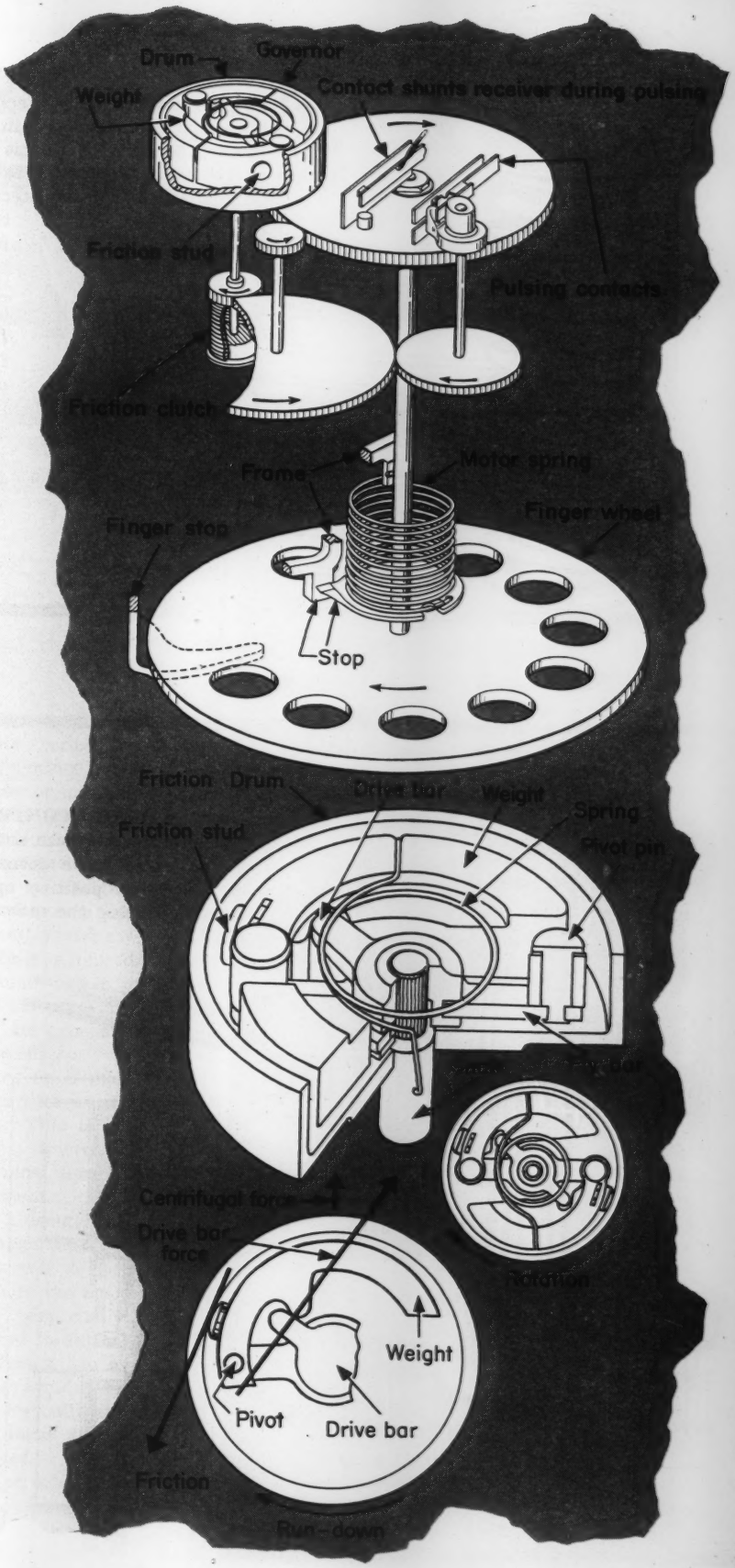
SCANNING the field for IDEAS



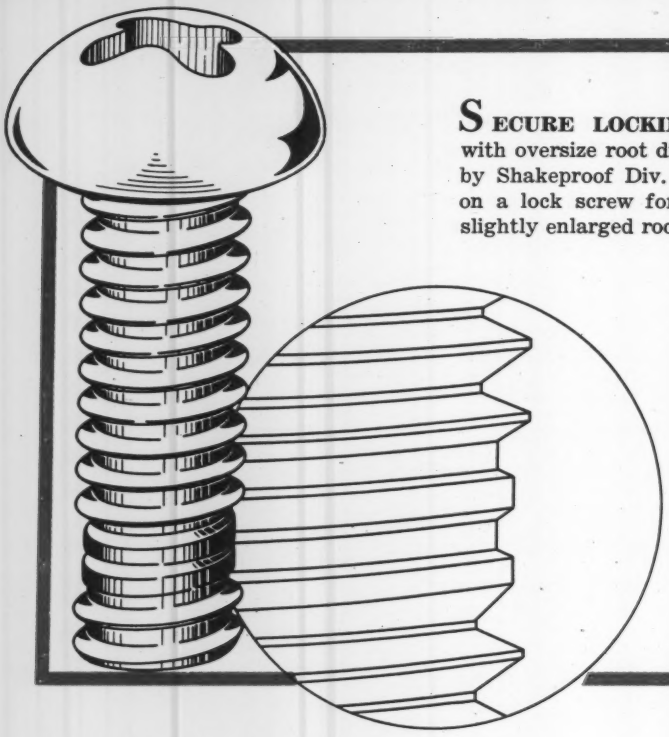
ACCURATE MEASUREMENT of high-range differential pressures is obtained mechanically with a helical sensing element developed by Foxboro Co. Unlike conventional single-turn Bourdon tube elements, the design employs a series of coils made from heavy-walled tubing, flattened and wound in helical form. High pressure enters the helical element directly while lower pressure goes to the outer housing. Differences in pressure between the inside and outside of the element cause the coils to wind and unwind, producing angular motion which is transmitted through the housing to a pen or pointer by means of a sealed bearing and pickup mechanism.

For straight pressure measurement, a heavy-duty helical design permits operation even in extreme pulsating service; possible ranges of measurement include spans from 0-50 to 0-80,000 psi. In operation, the design distributes the spring motion over a series of coils, reducing the resulting stresses and increasing fatigue life. The number of coils is dependent on the amount of rotation required for the pressure range selected, with allowance for overrange. The maximum pressure which each element is to withstand governs the selection of tubing wall thickness and form. Corrosion-resistant type 316 stainless steel produces the necessary spring characteristics over a wide pressure range with negligible hysteresis, assuring accurate measurement and repeatability.

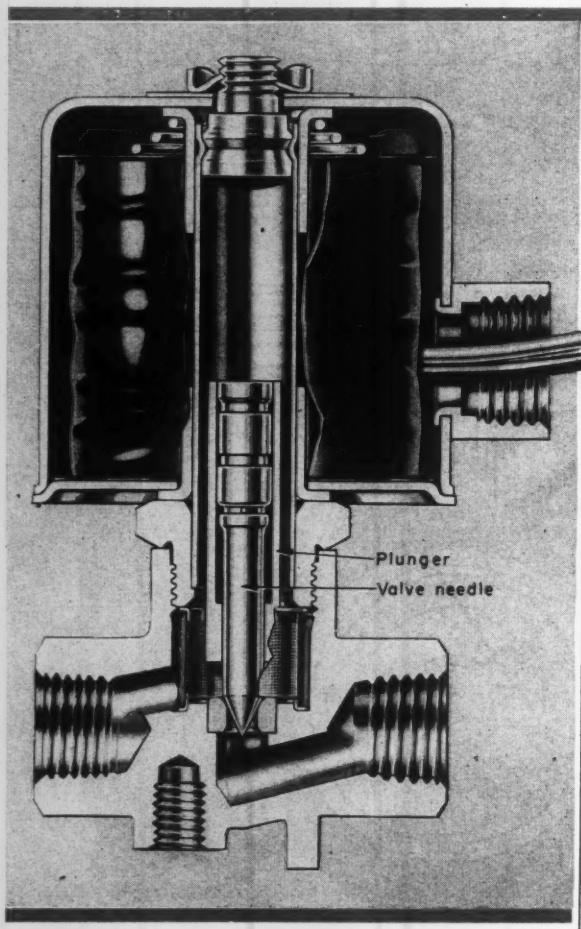
CENTRIFUGAL FRICTION GOVERNOR for small mechanisms provides accurate control of angular speed and torque and offers high reliability in a compact construction. Described in the *Bell Laboratories Record* by W. Pferd, a new type of governor developed for Bell System telephone dials utilizes a modified fly-ball mechanism to control dial run-down speed and assure uniform timing of signal pulses. Governor action is produced by two pivoted weights, driven by a drive-bar, which move outward against spring tension to engage the inner surface of a friction - drum through two friction studs. Governor speed is a function of the friction drag generated, the magnitude of the driving torque and the tension of the restraining spring. Uniform, accurate speed control is assured by the design which automatically compensates for changes in input torque; centrifugal force is assisted in maintaining frictional contact of the studs and drum by the braking action produced and by the drive force transmitted to the assembly through the drive bar. Performance of the governor under service conditions has shown substantial improvement over earlier designs and an ability to maintain satisfactory response characteristics under heavy or abnormal usage and friction variations.

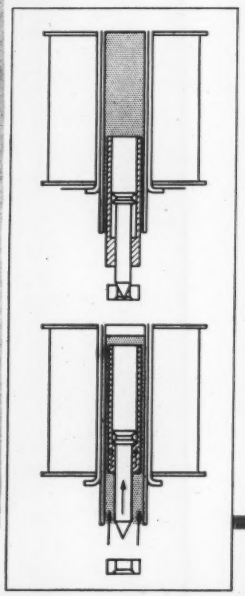


IDEAS



SECURE LOCKING of screw threads is obtained with oversize root diameters in a novel design developed by Shakeproof Div. of Illinois Tool Works. Employed on a lock screw for water faucets, the design utilizes slightly enlarged root diameters on two adjacent threads to produce an interference fit with the mating tapped hole. Easy starting of the screw is maintained by keeping the root interference a short distance from the screw end. The design offers possibilities in the joining of hardened metal parts or similar applications where conventional screw locking devices are not suitable.





IMPACT CONTROL of solenoid operation reduces coil size and operating current. In a solenoid valve design developed by A-P Controls Corp., positive opening action is achieved by utilizing the momentum of a plunger to drive a valve needle off its seat. When the solenoid is energized, the hollow plunger travels upward through a short distance toward the center of the coil magnetic field before striking the valve needle. The impact force produced assures positive operation even under high differential pressure conditions and acts to increase solenoid effectiveness, thus reducing coil size and initial current requirements. In the open position, the plunger floats in the magnetic field, dropping immediately into closed position when the solenoid is de-energized, thus providing a positive closing action.

A systematic method for analyzing and assigning

PRACTICAL TOLERANCES

By E. T. Fortini

Computer Dept.
Raytheon Mfg. Co.
Waltham, Mass.

IMPORTANCE of tolerances in product design and manufacture is universally recognized. Designers are usually on guard against specifying tolerances that are unduly close or unrealistic. Nonetheless, tolerances are often called for that result in unnecessarily high product costs.

There are many reasons for this situation. In some cases arbitrarily close tolerances are assigned because the relationships among tolerances and the conditions required for easy assembly and satisfactory operation have not been fully explored. Tolerances, therefore, are held to small values in the hope that proper functioning will automatically result. This practice is obviously an expensive substitute for correct tolerancing technique.

Tolerances can sometimes be opened up if manufacturing difficulties are encountered with no significant decrease in product quality. This is not always possible. For some designs, tolerances must be maintained at an uneconomical level in order to meet performance requirements. It is possible, and not uncommon, to have a design that will never perform satisfactorily regardless of close tolerances. If this is so, and there is neither time, inclination, nor money to eliminate the basic design fault, then expedients, usually very costly, are adopted and the incident is charged to experience. Occurrences of this sort are often taken as a matter of course. But they can be avoided by approaching the problem of tolerances logically and realistically: *instead of making tolerances fit the design, make the design fit the tolerances.*

First steps to do this must be taken when the design is still in the formative stage. Conditions that affect performance or assembly must be recognized and the surfaces that control these conditions located. Relations between the positioning tolerances for these surfaces and the desired conditions are deduced. It then remains to determine whether the conditions can be satisfied by employing practical tolerances. If the conditions cannot be satisfied by employing practical tolerances, the design must be modified toward that end. Several studies and consequent design modifications may be necessary before a satisfactory design is evolved.

This process is sometimes called *dimensional analysis.* A more appropriate name, however, is *dimension study,* as this avoids the ambiguity certain to arise from the use of a term that has another very different meaning.

A dimension study can be a very valuable design

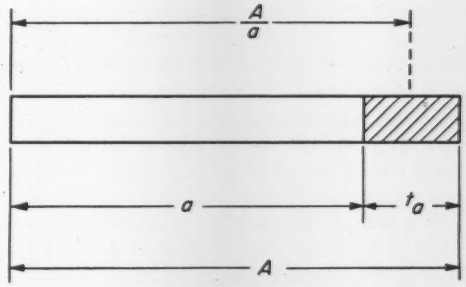


Fig. 1—Tolerance notation showing how the term A/a represents maximum/minimum values of a dimension having a tolerance t_a. That is, $t_a = A - a$

tool if correctly applied. Some of the uses of such a study are as follows:

1. To determine whether or not a design can perform according to requirements, insofar as these requirements are influenced by tolerances.
2. As an aid in obtaining results that are suited to functional and manufacturing requirements by indicating simple and direct methods for obtaining specific results.
3. To indicate the need of special manufacturing operations or the use of adjustments, shims, etc., when results cannot be obtained by simply using practical tolerances.
4. As a basis for preparing and checking manufacturing drawings.

The first three items are specific ways in which a dimension study can be used to make "the design fit the tolerances." The fourth item, even though it does not contribute directly toward the primary purpose of a dimension study, is nevertheless very important. The tolerances and dimensional relationships worked out by the designer must eventually be translated into working dimensions on manufacturing drawings. This is not easy for large complex jobs. Understandable notes must be made and kept on all final studies. If drawings are to be prepared by more than one person, then procedures must be worked out to assure that interrelated dimensions are properly assigned. Checking of drawings is greatly facilitated when complete and understandable records are available.

Procedures followed for a particular dimension study should be selected to suit the nature of the job. It does not make sense, for example, to apply the same type of a dimension study that is applicable to an accurate mechanism, such as a transit, to a rock crusher. The underlying principles in both cases would be the same, but the objectives and results of a study would be very different. It follows, therefore, that no rules can be stated to govern the extent of a study for a particular design; the decision depends on the nature of the design, the experience of the designer, the organization of the engineering force, and the factors that will influence manufacture, servicing, etc.

An example will be given to show how a dimension study can aid in designing for practical tolerances and, furthermore, how it can be used as the basis for computing and assigning dimensions for components. First, however, some of the elements of dimensioning technique will be briefly discussed.

Dimensions and Tolerances: The following definition has been given[1] for a *feature dimension:* "A dimension is a geometrical attribute of a part, such as a radius, diameter, length, or angle, of which the size is specified." A *positional dimension* is a co-ordinate used to locate either a single or a group of geometrical attributes.

Of the dimensions needed for describing a part it is generally true that only some of these have a direct bearing on assembly and performance. Those that do are usually called *functional dimensions.* There are two kinds of functional dimensions: dimensions of fits, and dimensions independent of fits. Examples of functional dimensions independent of fits are spring dimensions, dimensions of hydraulic orifices, lens curvature, etc.

Dimensions having no direct effect on assembly or performance, other than to satisfy the requirements of strength and rigidity, are called *constructional dimensions.*

A good rule to remember is that functional dimensions must always be held within specific limits. This is not necessarily so with constructional dimensions. The tolerances needed for satisfying functional conditions will have a pronounced bearing on the form of the final design. The manufacturing processes selected to yield the desired results at lowest cost depend largely on the size of

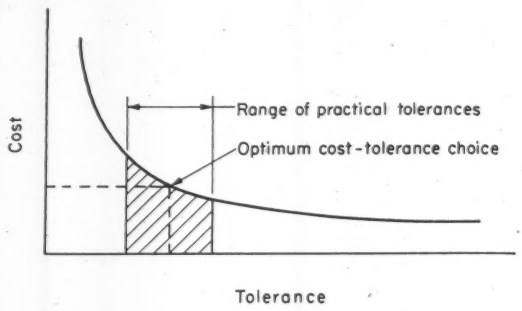
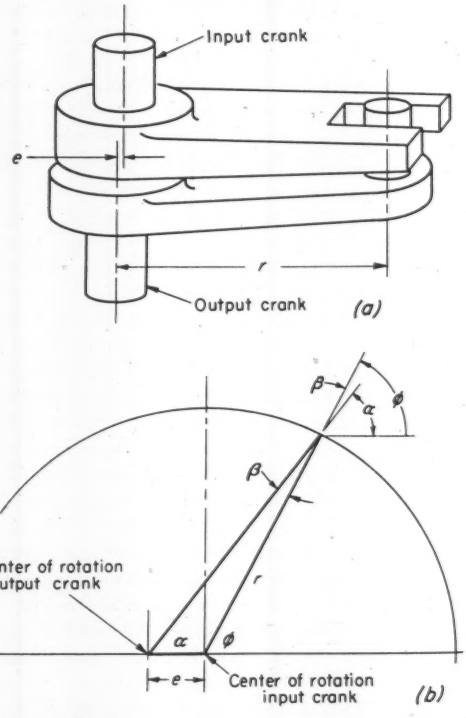


Fig. 2—Typical cost-tolerance relationship

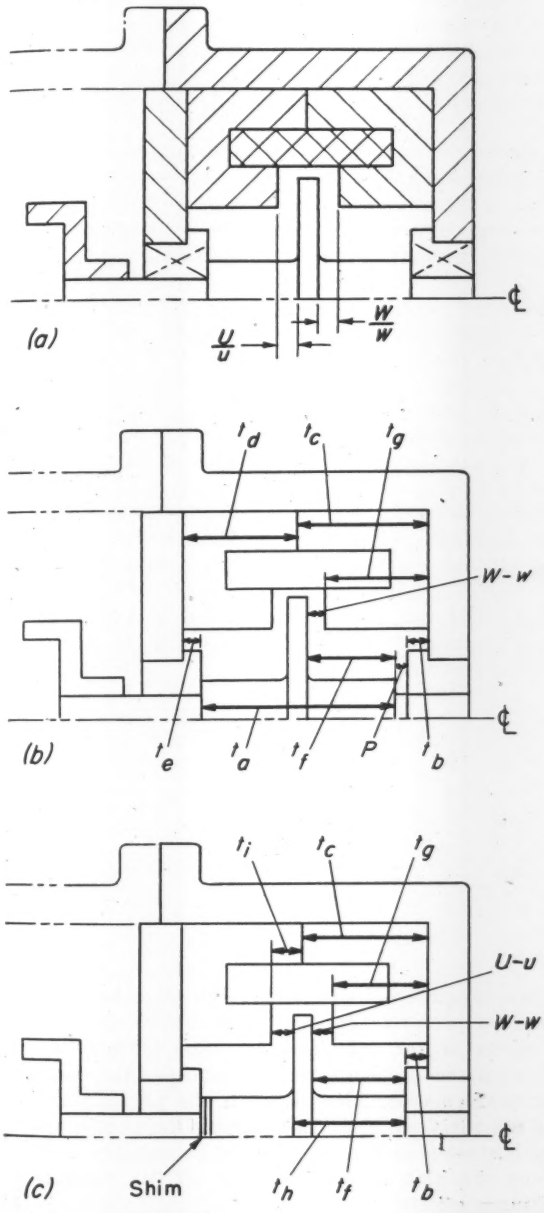
Fig. 3—For pin coupling at *a*, view *b* shows relationship of input and output angles and shaft misalignment *e*



the allowable tolerances. Needless to say, no design should be considered satisfactory if manufacturing operations are required that are unnecessarily expensive because of close tolerances.

Constructional features should be designed so that the normal tolerances associated with the manufacturing process under consideration are acceptable. Manufacturing processes should be chosen that will result in lowest cost.

Fig. 4—Simple example problem, *a*, requiring control of dimensions U/u and W/w. At *b*, the contributing tolerances in the original design are shown. Tentative solution at *c* shows effect of introducing adjustable shim



Notation: Dimensions and tolerances are expressed on drawings in a number of different ways. Following are three forms of the same dimension:

1. $2.500 \pm .005$
2. $2.505\ ^{+.000}_{-.010}$
3. $\dfrac{2.495}{2.505}$

It is not uncommon to find several methods of notation used on a single drawing. However, it is very helpful if a scheme of notation is used that will indicate whether or not a dimension is functional or constructional.

If a dimension is thought of as a variable bounded by maximum and minimum values, where the difference between maximum and minimum is the tolerance, then of the three forms considered, the third one seems to be the notation that expresses the dimension most concisely and directly. For the purpose of making a dimension study, it is convenient to use symbols such as A/a, B/b, etc., for dimensions whose values have not been determined. Upper case letters denote the maximum limit and lower case the minimum. The tolerance of A/a, $t_a = A - a$. *Fig.* 1 illustrates these simple concepts. This notation is recommended for functional dimensions.

Constructional dimensions can usually be specified by writing the nominal value only. A bilateral tolerance can then be associated with every dimension of this form by either suitably annotating the drawing or referring to a tolerance specification. Care must be exercised so that tolerances implied in this manner are representative of normal manufacturing practice. The nature of the design, as previously mentioned, should be such that normal manufacturing tolerances are acceptable for constructional dimensions.

In addition to feature and positional tolerances for length and angle dimensions, it is often necessary to specify limits for flatness, squareness, parallelism, symmetry, concentricity, and alignment. This is necessary when these geometrical attributes are not satisfied by feature and positional dimensions. Not only is it more difficult to evaluate the need for holding these characteristics to specific limits, but in many instances it is difficult to translate the requirements into understandable specifications. Nevertheless, the principles that apply to a dimension study involving lengths and angles have their counterparts when considering these characteristics.

Practical Tolerances: What are practical tolerances, and where can practical tolerance data be obtained? Answers to these questions are not entirely possible. Not enough data are generally

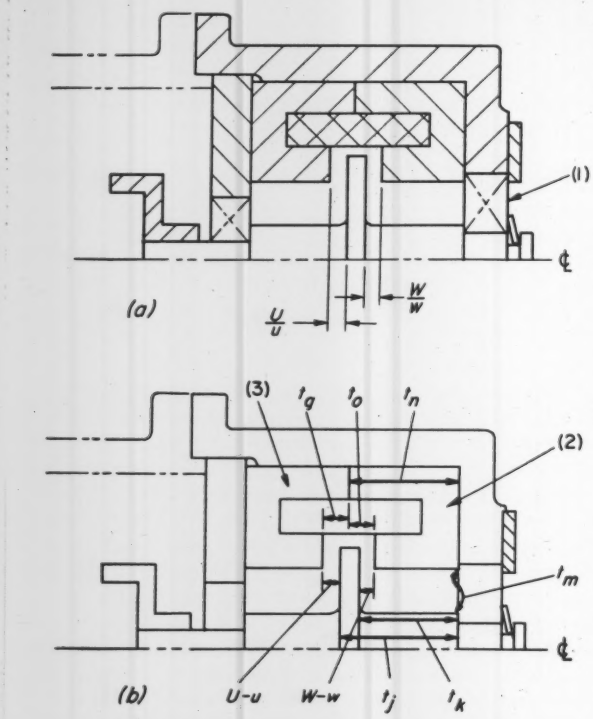


Fig. 5—Final redesign of example in *Fig.* 4. Dimension study led to design changes that provided control of U/u and W/w without need for a shim

available and much of the information that is available is not sufficiently qualified so that it can be intelligently applied. Nevertheless, suppose this definition is a starting point: A tolerance is practical when it will satisfy functional requirements and at the same time is limited to the inherent capability of the manufacturing process so as to be economically justifiable. This definition is in keeping with the idea that a tolerance is the link between design and production.[2]

Some of the factors that enter into a cost-tolerance relationship are the size, shape, and material of a part, the characteristics of the manufacturing process, and the quantity being produced. For a particular set of factors there is a cost-tolerance curve similar to *Fig.* 2. There is some point on the curve that represents the optimum cost-tolerance choice. In theory, assuming that sufficiently complete and accurate data are available, optimum tolerances can be determined. This is only possible if the necessary data are available, and they seldom will be. Even assuming that they are, the benefit realized by determining optimum tolerances may not warrant the effort expended, except for certain types of very precise mechanisms.[3] For most mechanical designs, therefore, the designer need only stay within the range of practical tolerances to make an acceptable choice.

An ideal situation is to design for specific machine tools and processes where the *natural tolerances* have been determined by statistical methods. The working tolerance used by the designer will be somewhat larger than the natural tolerance. A factor of one-third greater has been suggested. This allows for repeating settings of the same job and for using new tools and dies.[4]

Since not all manufacturers use statistical quality control methods, exact information about machine or process performance may not be available. This will be especially true for shops where production quantities are small. Data in such a case may be obtained by consulting shop personnel. This, however, may not prove satisfactory. A good idea is for management to make surveys of machine capabilities.[5] Results sufficiently reliable for most requirements can be based on measurements of work in process.

Many designers are faced with the task of designing for unknown shops. Most of their tolerance information must be gleaned from books and periodicals. While some of this information is accurate and valuable, much of it is not applicable to a large variety of work. By carefully accumulating, comparing, sorting, and classifying what data does come to his attention, a designer can assemble a good file of source material.

Tolerance and Performance: The relationship between tolerance and performance is sometimes obvious. Consider a journal bearing. Two dimensions control the fit; the possible variation is, therefore, the sum of two tolerances. Not all relationships are so simple or obvious. Sometimes the tolerance-performance relationship can be determined by analysis. As an example, take the pin coupling shown in *Fig.* 3*a*. Suppose the problem is to determine what effect the shaft misalignment will have on the output rotation, assuming the input to be a constant rotational speed. If ϕ is the input angle and α the output, then from *Fig.* 3*b* the difference between these angles is β. Using the law of sines,

$$\frac{e}{r} = \frac{\sin \beta}{\sin \alpha}$$

or

$$\beta = \sin^{-1}\left(\frac{e}{r} \sin \alpha\right)$$

When $\alpha = 90$ deg, β is a maximum; therefore,

$$\beta_{max} = \sin^{-1}\left(\frac{e}{r}\right)$$

This illustrates a case where the effect of tolerances on performance can be explicitly expressed in terms of the tolerance condition. There are other tolerance conditions that influence the coupling performance: play between the pin and slot and the variation of r. The extreme limits of coupling performance can be obtained by suitably combining the high or low limits of all the separate tolerance effects.

One of the most important ingredients of a tol-

erance-performance study is the ability to recognize the relative importance of the factors involved. Consideration should be restricted to tolerance conditions that have a significant effect on performance. Establishing all tolerance-performance relationships will generally be neither possible nor practical.

Because tolerance-performance relationships are virtually unlimited, the method of solution for many problems will be unique. Some types of problems do occur so often that the method of solution can be made routine. This is true of the technique for handling combinations of length dimensions. Examples of this type will follow.

For the purpose of showing the reasoning process, the first example is particularly simple. For many designs normal intuition and judgment will often be enough to lead toward a satisfactory result. This is more generally so for simple, straightforward designs. For complex designs, however, intuition and judgment will often be inadequate.

An Example: For the design shown in *Fig.* 4*a*, a requirement is that the gaps U/u and W/w be held within specific limits. Suppose that from experimental data or from analytical consideration it has been determined that the width of both gaps should be between 0.062 and 0.050-inch. Thus $U - u$ and $W - w$ must not be greater than 0.012.

The dimensional relationships that control the gaps are shown schematically in *Fig.* 4*b*. The shaft end play is

$$p = t_a + t_b + t_c + t_d + t_e \quad \ldots\ldots (1)$$

Similarly, the variation of the gap is

$$W - w = t_b + t_f + t_g + p \quad \ldots\ldots (2)$$

Substituting Equation 1 in 2 gives an expression for the maximum possible variation of gap width in terms of the maximum tolerance values:

$$W - w = t_a + 2t_b + t_c + t_d + t_e + t_f + t_g \quad \ldots\ldots (3)$$

In actual practice extreme conditions are not likely to occur. Wherever possible the designer should make use of statistical techniques in order to evaluate the effect of tolerances as they will most probably happen. An extremely simple and workable proposal toward this end is given in *Reference* 2. Statistical techniques will not be introduced in this discussion, which will be limited to the simplest elements of a tolerance study.

Once a relationship like Equation 2 has been deduced, the next step is to assign tolerance values. It often happens, as in this instance, that some of the tolerances will have preassigned values because they are tolerances on purchased parts. This is true of the bearing tolerances t_b and t_e. Suppose

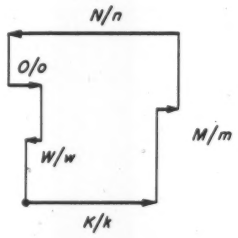


Fig. 6 — Vector diagram of closed dimension loop

$\frac{W}{w} = \frac{0.060}{0.050}$ Functional requirement

$\frac{M}{m} = \frac{0.005}{0.000}$ From Mfr. catalog

$\frac{N}{n} = \frac{1.002}{1.000}$ } Assigned

$\frac{O}{o} = \frac{0.253}{0.250}$ }

Calculation of $\frac{K}{k}$

$\sum \overleftarrow{max} + w$	$\sum \overrightarrow{min}$
1.002	k
0.050	0.000
	0.250
1.052	$k + 0.250$

$k = 0.802$

$K = k + t_k = 0.802 + 0.002 = 0.804$ – inch

Fig. 7—Work sheet for assigning and calculating dimensions for *Fig.* 6

that for this discussion

$$t_b = t_e = 0.010\text{-inch}$$

Substituting this numerical value in Equation 3,

$$W - w = 0.030 + t_a + t_c + t_d + t_f + t_g$$

As previously noted, $W - w$ should not be greater than 0.012. The conclusion is obvious; the design as it stands is unsatisfactory.

Much of the difficulty with the design is due to the axial play of the shaft. Modifying the design by introducing an adjustable shim, as shown in *Fig. 4c*, will eliminate the play. The variation of the gap for this new arrangement is

$$W - w = t_b + t_f + t_g$$

Compare this new equation with Equation 3; an improvement is evident, but is it enough to make the design satisfactory? As before, substitute t_b for its known value, so that

$$W - w = 0.010 + t_f + t_g \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

To satisfy the requirement that $W - w$ cannot be greater than 0.012 the sum of the tolerances t_f and t_g must not exceed 0.002. Now, examine the other gap. From *Fig. 4c*,

$$U - u = t_b + t_c + t_h + t_i$$

or, again substituting the known value of t_b into the equation,

$$U - u = 0.010 + t_c + t_h + t_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Since both Equations 4 and 5 must satisfy the same condition, the chief concern is with the more difficult case, Equation 5. Here the sum of three tolerances, t_c, t_h, and t_i, must be less than 0.002-inch. If tolerances of approximately 0.0007-inch are considered unacceptable, and it is assumed they are, then the design is again unsatisfactory.

One is now in a position to develop the design along more favorable lines because of the knowledge gained. Two things are evident, axial shaft play and the effect of bearing tolerance t_b must be effectively eliminated. A different bearing arrangement can be worked out so as to use bearings that do not have the large tolerance inherent with the flanged bearings used so far. Axial shaft play may again be eliminated by the use of shims, but first an attempt should be made to design for no axial play without the use of shims. *Fig. 5a* shows how the design has been modified to satisfy these objectives. The shaft is located on one bearing, the other end is allowed to float. Assume bearing (1) has a variation between the face of the outer and inner ring of 0.005-inch.

The dimensional relationships for both gaps are shown schematically in *Fig. 5b*. The method of assigning the dimensions that control the gap W/w has been selected so that parts (2) and (3) will be identical. It will be recalled that in the previous design this was not considered. The variation across the gap is

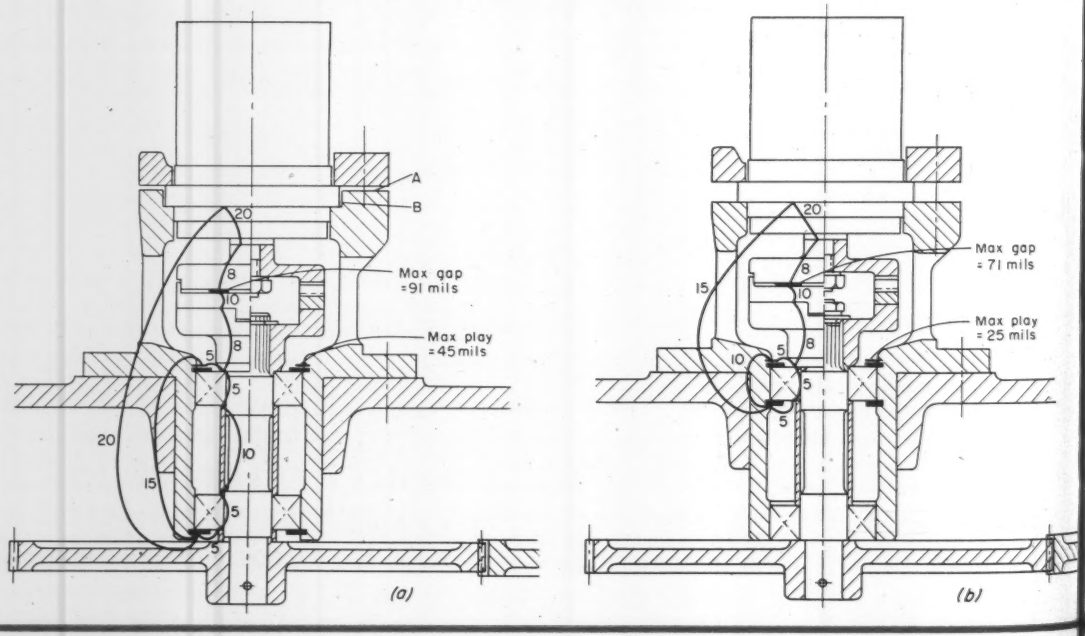
$$W - w = t_k + t_m + t_n + t_o$$

and

$$U - u = t_j + t_m + t_n + t_q$$

If there are substituted in these formulas 0.005 for

Fig. 8—Example, *a*, of simple notation that can be used to record a dimension study. Final dimension study, *b*, becomes the basis for dimensioning of detail drawing



t_m and 0.012 for both $W - w$ and $U - u$, then

$$t_k + t_n + t_o = 0.007\text{-inch}$$

and

$$t_j + t_n + t_q = 0.007\text{-inch}$$

These formulas are satisfied if $t_k = t_j = t_m = 0.002$ and $t_o = t_q = 0.003$. It will be assumed that these are practical tolerances for the application. The design then can be considered acceptable insofar as the requirement for holding the gaps between the limits 0.050/0.062 is concerned.

Assigning and Calculating Dimensions: The preceding example has shown how, in the process of design, functional dimensions have been located and tolerances determined. These results must be translated into actual dimensions.

Two dimension loops are contained in *Fig.* 5*b*. One of these will serve as an example, and is shown as a vector diagram in *Fig.* 6. All of the vectors except one represent actual dimensions. The exception is the tolerance condition $W - w$. One of the relationships contained in the diagram was used in the development of the design. That is, the variation $W - w$ is equal to the sum of the dimension tolerances, or symbolically,

$$v_w = \Sigma t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

There are two other relationships in the diagram:

1. The minimum condition (in this case w) plus the sum of the maximum limits of the dimensions in the same direction is equal to the sum of the minimum limits of the dimensions in the opposite direction.
2. And conversely, the maximum condition (in this case W) plus the sum of the minimum limits of the dimensions in the same direction is equal to the sum of the maximum limits of the dimensions in the opposite direction.

These relationships are expressed symbolically:

$$\sum \overleftarrow{\text{max}} + \overleftarrow{w} = \sum \overrightarrow{\text{min}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\sum \overleftarrow{\text{min}} + \overleftarrow{W} = \sum \overrightarrow{\text{max}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Only two of the three equations (6, 7, and 8) are necessary. In fact, given any two, the third may be deduced. Normal procedure is, with Equation 6 already applied in the process of design, to make use of either Equation 7 or 8 for calculating dimensions.

Referring again to *Fig.* 6, the values of all known dimensions are listed and values assigned to all unknown dimensions except one; this dimension must be calculated. The limits of the assigned dimensions will depend on the nominal values of the dimensions, scaled from the design layout, and on the tolerances previously selected to satisfy the functional condition. Computations are shown in *Fig.* 7.

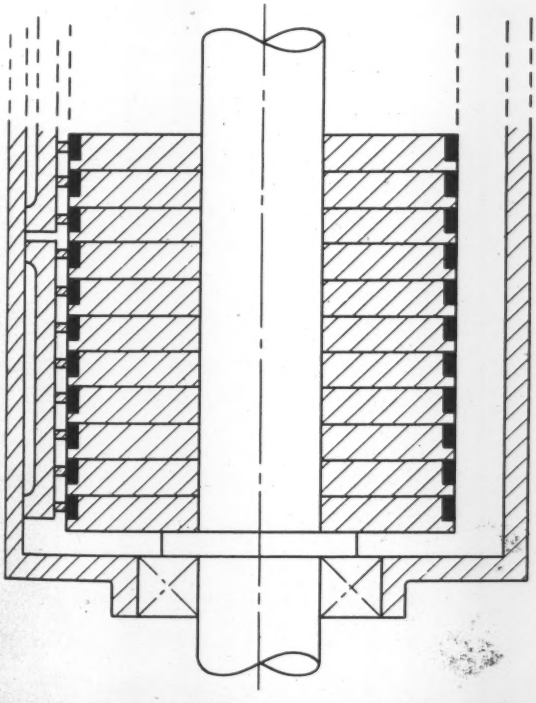
The utility of tabular methods of computation may not be evident from the example given. Indeed, this presentation could have been made in some other form. However, where many dimensions are involved tabular methods are almost indispensable.

Further Examples: The technique used in the preceding example for determining whether the conditions necessary for proper functioning could be satisfied with realistic tolerances is more academically thorough than practical. In actual use the process would normally be carried through in a highly compressed form, either mentally or with the aid of simple notation. *Figs.* 8*a* and 8*b* show one of the possible methods. Work of this nature can be done on transparent paper placed over the design layout or directly on a print of the layout if one is available.

Usually a designer considers more than one solution for a design problem. Since the relative merits of these may not be obvious, a careful analysis will sometimes be required before a choice is made. This is one of the most important uses of a dimension study. Of course, the dimension study will not be the only factor that will influence the decision; it will, however, be an important one.

Sometimes a dimension study will indicate improvements quite independent of tolerance consid-

Fig. 9—Slip-ring assembly, typical of designs requiring compensation for large tolerance accumulations



erations. An apparent oversight was revealed in the design shown in *Fig.* 8*a* as a result of the dimension study, surface "A" and bore "B" have no functional purpose and could easily be eliminated. This was done in *Fig.* 8*b*.

It is the nature of some designs that tolerance effect in one part must be considered before designing other parts. The slip ring assembly shown schematically in *Fig.* 9 is an example of this. The problem was to determine how many brushes a brush holder should carry using rings ¼-inch wide and brushes 3/16-inch wide, thus allowing a possible variation of ⅛-inch in the location of the extreme rings and brushes. This variation can compensate for the tolerance build-up: thickness tolerance of a ring (0.012) times the number of rings (N) for one brush holder, plus the spacing tolerance of the extreme brushes (t), or

$$0.012\,N + t = 0.125$$

Another requirement was that N should be a factor of 24, the total number of rings. After a few trial substitutions in the formula the number of brushes in one brush assembly was selected as 8, thus allowing 0.029-inch spacing tolerance between the end brushes.

Frequently a dimension study will indicate that an entirely different approach to a problem is necessary. For instance, instead of sector gears to rotate parallel, offset shafts through equal angles from 30 to 150 deg with a 1:1 ratio, a parallelogram linkage was proposed; a study of the accuracy requirements had indicated that the cost of sufficiently accurate gears would be prohibitive.

Summary: In the foregoing discussion the barest elements of a dimension study have been considered. Examples have been given for the purpose of presenting, somewhat formally, the mechanics of a simple dimension study, and for showing applications of the study to actual problems. This discussion has only touched the fringe of a technique that, properly applied, can be useful in assuring that performance at reasonable cost will be designed into a product as far as tolerances are concerned.

REFERENCES

1. *Dimensional Analysis of Engineering Designs,* Vol. I, Components (Part I); Ministry of Supply, HMSO, London 1948; Page 110.
2. J. Gilson—*A New Approach to Engineering Tolerances,* Machinery Publishing Co. Ltd., London, 1951.
3. Eugene Pike and Thomas Silverberg—"Assigning Tolerances for Maximum Economy," MACHINE DESIGN, September 1953, Page 139.
4. Dorian Shainin—"Quality Control Methods," MACHINE DESIGN, January 1953, Page 153.
5. Dorian Shainin, "Predicting Machine Capability," MACHINE DESIGN, January 1950, Page 72.

CONTEMPORARY DESIGN

Recorder Combines Attractive Appearance and Utility

SIMPLICITY of form, ease of operation, ease of maintenance and neat appearance are combined in Illinois Tool Works' 1603 electrical recorder. A permanent record of the condition of a surface inspected by an analytical measuring machine, or a hob and worm lead machine, is provided by the recorder which operates on 115 volt 60 cycle ac. Styled by Reinecke and Associates, black top and red and white nameplate are in pleasing contrast to the simple, green-gray housing. Three-point base with cutout allows the operator to stand close to the machine during operation. All frequently used controls such as pen positioner and on-off switch are located on the top control panel. An acrylic plastic cover over the ink container, pen and ink starter and chart is easily slid back to allow access to those items and the graph. Indirect lighting of the Lucite cover illuminates the graph and also serves as a pilot light to indicate when the recorder is in operation.

A new concept—the slide-sweep ratio—aids selection of addendum ratio for most favorable

GEAR-TOOTH LUBRICATION

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MANY recommendations have been made for the best ratio of the addendums of pinion and gear in a pair of mating spur or helical gears. Differences between the recommendations are in many cases due to the fact that different considerations have some influence on the matter. In this article an aspect of the lubrication of the teeth is discussed. This is of special importance in high-speed gears and it suggests how the most suitable addendum-ratio for such gears may be determined. It is not suggested that anything is to be gained in this respect by using nonstandard gear-cutting tools, but that the selection of blank diameters for a proposed pair may usefully take into account this matter of lubrication.

The Slide-Sweep Ratio Concept: The sliding conditions in the contact of a pair of gear teeth vary from point to point and, rather curiously, are not the same for the two surfaces even at a single point of contact.

In most gears the contact between any pair of teeth in ideal conditions is a line. In involute gears the contact line is a straight line and the conditions of contact at any instant approximate those applying to the contact of two cylinders with parallel axes. It is convenient for the purposes of analysis to think of the contact as occurring between two such cylinders rotating at fixed angular velocities relative to the plane of their axes.

The surfaces have a common rubbing speed which is the difference between the peripheral velocities of the cylinders (or disks) where they intersect the plane of the axes at the contact line.

The line of contact sweeps over either surface at a velocity equal and opposite to the peripheral velocity of the disk concerned. This velocity is here called the *sweep velocity* for the surface; it is the velocity of the contact line over the surface in the direction perpendicular to the line.

In the past, the sweep velocity has been called the "rolling velocity" for reasons that seemed satisfactory at the time, but the name is misleading in that rolling is usually understood to mean the relative motion of bodies in contact without slip, whereas it is necessary for some purposes to consider the sweep velocity of surfaces that are slipping (sliding or rubbing) on each other, and that is in fact the normal condition of contact between gear teeth.

If two contacting surfaces are A and B, the ratio of the sliding velocity of B on A to the velocity with which the contact-line moves over A is called the *slide-sweep ratio* for A. Similarly the slide-sweep ratio for B is the ratio of the sliding velocity of A on B to the velocity of the contact line over B. In general the slide-sweep ratios for the contacting surfaces are unequal and so the lubrication conditions are not the same for both although they necessarily have a common sliding speed.

If the peripheral velocities of disks A and B at

TABLE 1

$S_A = 0$ and $S_B = 0$ (Case 2)

This is the case of rolling contact and no question of friction arises. If the sweep velocity (in this case the rolling velocity) is low, an oil film on the surfaces may be squeezed out ahead of the line of contact. If the sweep velocity is high, a high hydrodynamic pressure may be built up in the film and metallic contact avoided.

$S_A = 1$, $S_B = \infty$ (Case 4)

Because $S_A = 1$, the velocity of B over A is equal to the sweep velocity on A and so the same line on B touches A at all instants. Since any imperfection in the lubrication causes all the ill effect on B to be concentrated on a single line on B, this is not a desirable condition for long life of the surfaces if, as is often the case, the oil may contain abrasive solids.

$S_A = 2$ and $S_B = 2$ (Case 6)

This condition can conceivably be a very poor one. The movement of B relative to A may induce in the oil film an action comparable with the carrying of B on a series of parallel cylindrical "needles" which are rolled over A by the relative movement of B at half the "sliding" velocity. Because the sweep velocity is also half the sliding velocity, the needle of oil at the nominal line of contact of the surfaces remains with it as it moves over A with the sweep velocity. The heating effect induced in the oil by viscosity opposed to this rotation of the needle is thus concentrated in one small volume of oil which is rapidly heated, loses viscosity and tends to permit metallic contact between the surfaces. If this happens, the surfaces may suffer the local incipient welding known as "scuffing" and failure of surfaces of similar materials may occur quickly. If the materials are markedly dissimilar, serious welding is unlikely but, for example, an extremely thin layer of bronze may firmly adhere to a mating steel surface.

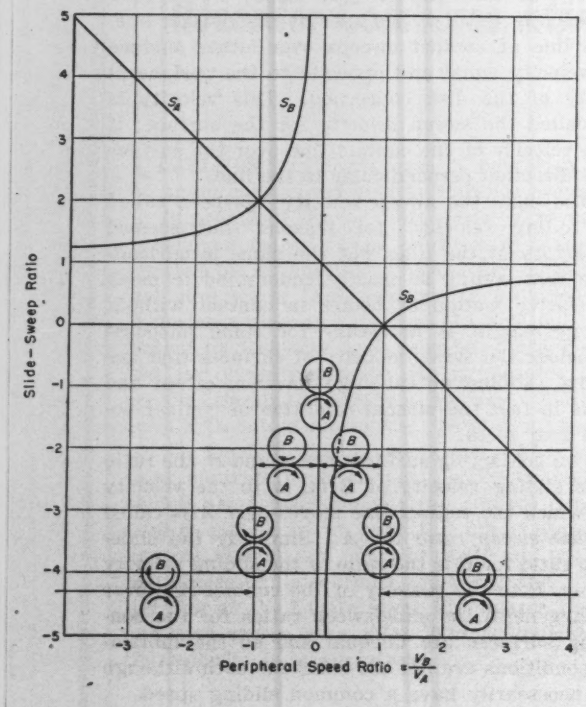
S_A greater than 1, S_B greater than 1 (Case 5)

In this condition a point of B that has just made contact with A is moving faster over A than does the line of contact on A. Consequently there is a tendency for oil that has been heated by the relative sliding that occurs under load at the contact line to be carried forward onto the part of the oil film of A that the contact-line is approaching. The oil on A may thus be weakened by heat (and possibly contaminated by solid matter worn from the surfaces if lubrication is imperfect) just before the contact line reaches it and so its capacity for taking load is reduced.

Since the same considerations apply to B, this combination of slide-sweep ratios is not conducive to good lubrication.

Examination of Equations 1 and 2 shows that for both S_A and S_B to be greater than 1, v_A and v_B must have opposite signs, corresponding to the rotation of disks with opposite peripheral velocities

Fig. 1 — Slide-sweep ratio versus peripheral-speed ratio of disks rotating in contact. Action of disks in each region of graph can be visualized from the relative lengths of velocity "vectors" in the pictured disks



the common plane of their axes are v_A and v_B, sliding speed of A on $B = v_A - v_B$ in the direction of motion of the disks at their line of contact.

Now the velocity of the contact line over the surface of B is in the opposite direction to the velocity of the surface at the common plane of the axes. Hence, sweep velocity for $B = -v_B$. Therefore, the slide-sweep ratio for B is

$$S_B = \frac{v_A - v_B}{-v_B} = 1 - \frac{v_A}{v_B} \qquad (1)$$

Similarly the slide-sweep ratio for A is

$$S_A = 1 - \frac{v_B}{v_A} \qquad (2)$$

From Equation 1 $v_A/v_B = 1 - S_B$, and so from Equation 2,

LUBRICATION EFFECTS OF SLIDE-SWEEP RATIO

Case	Slide-Sweep Ratio S_A	Slide-Sweep Ratio S_B	Lubrication Conditions for A	Lubrication Conditions for B	Relation of Surface Speeds
1	Negative	Between 0 and 1	Good	Good	$v_B > v_A$
2	0	0	Good	Good	$v_B = v_A$
3	Between 0 and 1	Negative and less than $-S_A$	Good	Good	$v_B < v_A$
4	1	Infinite	Not good	Bad	$v_B = 0$
5	Between 1 and 2	Greater than S_A	Bad	Bad	$0 > v_B > (-v_A)$
6	2	2	Very bad	Very bad	$v_B = -v_A$
7	Greater than 2	Less than S_A but not less than 1	Bad	Bad	$v_B < (-v_A)$
8	Infinite	1	Bad	Not good	$v_A = 0$

at the line of contact. While each disk is bringing a film of oil toward the contact line, the other disk is tending to drag it away and this also suggests indifferent lubrication conditions.

S_A between 0 and 1, S_B negative (Case 3)

The conditions here are opposite to those of the previous case in that the relative motion of the surfaces does not tend to induce oil heated at the contact line to move ahead of the contact line. On A the heated oil tends to be moved by B in the same direction as the motion of the contact line but at a lower speed. On B the heated oil tends to be moved by A in the opposite direction to the motion of the contact line.

On each surface, therefore, the contact line moves onto an oil film that has not been affected in any way by the immediately preceding contact and, to this extent, lubrication conditions are favorable.

Equations 1 and 2 show that for S_A to be positive and S_B negative, v_A and v_B must have the same sign, corresponding to rotation of disks with peripheral velocities in the same direction at the line of contact. Both disks thus tend to draw oil to the line of contact and the conditions are therefore favorable for lubrication. They are not, however, the same for both surfaces.

An undesirable condition may arise, however, if the slide-sweep ratio for either surface has a very large negative value (say less than -20), because if there is abrasion by foreign matter in the lubricant, the effect is concentrated on a small area of that surface.

General Comparison of Cases

Case 1 is the converse of Case 3, Case 7 of Case 5, and Case 8 of Case 4.

Any case in which the slide-sweep ratio for either surface exceeds unity gives less satisfactory lubrication conditions than do the others.

Any case in which the slide-sweep ratio for either surface is numerically great (either positive or negative) is undesirable since any tendency toward abrasion is concentrated on a small part of that surface. Furthermore, the ratio for the other surface is near the boundary value (unity) between good and bad conditions.

$$S_A = 1 - \frac{1}{1 - S_B} = \frac{S_B}{S_B - 1} \quad \ldots\ldots (3)$$

and similarly

$$S_B = \frac{S_A}{S_A - 1} \quad \ldots\ldots (4)$$

There is thus a reciprocal relation between the slide-sweep ratios of mating surfaces and some important details of the relation are summarized in *Table* 1 and *Fig.* 1.

GEAR-TOOTH LUBRICATION

Slide-Sweep Ratio on Spur Gear Teeth: *Fig.* 2 represents the contact, at A, of two teeth of a pair of involute spur gears. In every phase of engagement the contact point lies on the common tangent B_1B_2 to the base circles and at the point of contact, the two profiles are perpendicular to B_1B_2. The slide-sweep conditions are therefore those determined by the velocities of the profiles at A relative to the line B_1B_2 corresponding to the line of centers of contacting circles.

Clockwise rotation of the upper gear with angular velocity ω_1 relative to the plane of the axes causes the point A of intersection of the profile with the tangent B_1B_2 to the base circle to move away from the center O_1. In relation to the upper gear, the kinematic effect is the same as that of rolling of a tangent around the base circle in the counterclockwise direction with angular velocity ω_1. The instantaneous center of rotation of the tangent is B_1 and its velocity at A relative to the tooth is therefore $\omega_1(AB_1)$ outward, i.e., downward. Conversely the velocity (relative to B_1B_2

and perpendicularly to it) of the profile of the tooth of the upper gear at A is $\omega_1(AB_1)$ upward. Similarly the velocity of the profile of the tooth of the lower gear at A is $\omega_2(AB_2)$ upward.

The velocities are in the same direction for all possible positions of A and so the slide-sweep ratio is always between 0 and 1 for one tooth and negative for the other. Conditions are thus everywhere favorable to lubrication, as will be seen later on.

Now $(AB_1) = (PB_1) - (PA)$ and $(AB_2) = (PB_2) + (PA)$. Since the gears have a common circumferential speed at the base circles, $\omega_1(O_1B_1) = \omega_2(O_2B_2)$. By similar triangles $(O_1B_1)/(O_2B_2) = (PB_1)/(PB_2)$, and so $\omega_1(PB_1) = \omega_2(PB_2)$.

Now $\omega_1(AB_1) = \omega_1(PB_1) - \omega_1(PA)$ and $\omega_2(AB_2) = \omega_2(PB_2) + \omega_2(PA)$.

The slide-sweep ratio S_1 for the upper gear is

$$S_1 = \frac{\omega_2(AB_2) - \omega_1(AB_1)}{-\omega_1(AB_1)} = \frac{(\omega_1 + \omega_2)(PA)}{\omega_1(PA) - \omega_1(PB_1)}$$

$$= \frac{1 + \frac{\omega_2}{\omega_1}}{1 - \frac{(PB_1)}{(PA)}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Similarly

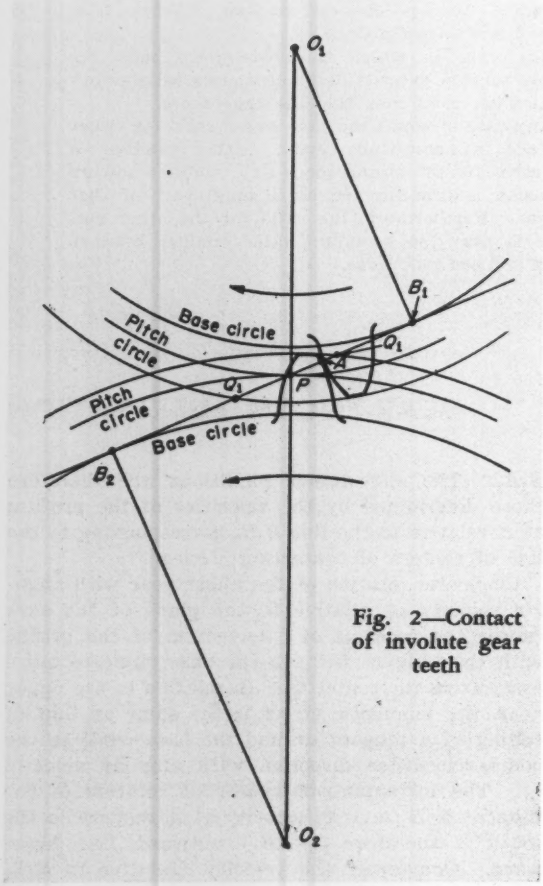


Fig. 2—Contact of involute gear teeth

$$S_2 = \frac{1 + \frac{\omega_1}{\omega_2}}{1 - \frac{(PB_2)}{(PA)}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

In using these expressions PA is to be given a positive value if A lies between P and the point of contact of the tangent and the base circle of the gear concerned.

For example, considering S_1, its value is negative so long as PA is positive, since PA cannot exceed PB_1. If PA approaches the value PB_1, S_1 has a large negative value. When PA is negative, S_1 is positive, the maximum value being attained when PA reaches its negative maximum which is $-PB_2$. In that case, from Equation 5, $S_1 = 1$ and, from Equation 6, $S_2 = \infty$.

This case is a physical possibility if the tip circle of the upper gear contains the point B_2, but gears can (and should) be designed so that this condition of contact near the base circle is avoided. It may be unavoidably approached in the smaller gear of a pair and $(PB_1)/(PA)$ may be about 4/3 with ω_2/ω_1 not exceeding 1. Then $S_1 = (1+1)/(1-1\frac{1}{3}) = -6$, and $S_2 = -6/(-6-1) = 0.86$.

This case represents about the least favorable condition encountered in good practice. In high-speed gears, where the number of teeth in the smaller gear may exceed 30, the least favorable condition may correspond to about $S_1 = -0.5$ and $S_2 = -0.5/(-0.5-1) = 0.33$.

The important general fact about the contact of spur, helical and bevel gears on parallel shafts in this connection is that the slide-sweep ratio is negative at points inside the pitch surface of engagement of the gear concerned and positive, but less than unity, at points outside it. Thus the undesirable condition of a slide-sweep ratio exceeding unity is avoided by the essential geometry of the involute system and it is this that makes it possible to mate pairs of gears of materials that could not be satisfactorily run together as a shaft and a bearing, for example.

Spur, helical and bevel gears are commonly made from steel with only small differences in composition between the members of a pair and a satisfactory lubricant can be found for any conditions likely to be encountered. If the slide-sweep ratio were to exceed unity, this would not necessarily be the case and indeed in worm gearing, where the slide-sweep ratio does exceed unity, the choice of materials is rather severely restricted. For the heaviest duty the only useful combination is that of case-hardened steel for the worm and phosphor bronze for the worm gear. For lighter loading and low speeds a few alternative combinations are permissible but others fail by seizing and scoring even under very light loading and with good lubrication.

Equalizing Slide-Sweep Ratios: In *Fig.* 2 the instantaneous center of rotation of the upper gear about the lower one is the point P, and the relative angular velocity of the gears is $\omega_1 + \omega_2$. Hence the sliding velocity at the point A is $(PA)(\omega_1 + \omega_2)$.

For given angular velocities, the sliding velocity

increases with the distance of the point of contact of the teeth from the point of contact of the pitch circles. The maximum value of this distance occurs when A is on the tip circle of either gear and so is determined by the greater of the addendums of the gears and by the transverse pressure angle. The sum of the addendums is a constant for the particular pitch and form of the tooth. The maximum addendum can be given its minimum value, if a standard tooth form is used, by minimizing the pitch of the teeth. This is accepted practice in the interest of less noise from high-speed gears.

Because the lubrication conditions with positive slide-sweep ratio are not ideal, there is reason for considering how the maximum slide-sweep ratio for gears of given pitch and numbers of teeth may be minimized.

If the curvature of the tip circle of the lower gear in *Fig.* 2 be neglected, the maximum value of PA is addendum of lower gear times cosec ϕ where ϕ is the transverse pressure angle and the corresponding maximum value for the upper gear is cosec ϕ times difference of working depth and addendum of lower gear.

After substituting these values in Equations 5 and 6, it is possible to calculate what ratio of the addenda of a pair of gears will equalize the maximum slide-sweep ratios of the two gears. The result depends on the number of teeth in the pinion, the velocity ratio and on the ratio of working depth to the pitch of the teeth. Variations in the result from variations in velocity ratio are small, and it is possible after examination of them to set down simple formulas that apply very closely for a velocity ratio of 5 and are sufficiently accurate to be accepted as guidance for all ratios up to 12 to 1.

GEAR-TOOTH LUBRICATION

At least 10 teeth in the pinion and 20 teeth in the gear are assumed. The formulas are

$$\text{Pinion addendum} = (\text{working depth})\left(0.5 + \frac{2.5}{n}\right)$$

$$\text{Gear addendum} = (\text{working depth})\left(0.5 - \frac{2.5}{n}\right)$$

where n is the number of teeth in the pinion. For values of n normally used for high-speed gears, this formula makes the addendum of the pinion between 0.5 and 0.6 times the working depth. In some circumstances (not connected with lubrication) it may be necessary to use an addendum that is a greater fraction of the working depth; this tends to make the lubrication problem more difficult than it need be.

Example: Approximate values of maximum sliding speed and maximum slide-sweep ratio for a pair of high-speed gears are calculated as follows:

	Pinion	Gear
Speed (rpm)	6000	1000
Number of teeth	40	240
Pitch diameter (in.)	7.6	45.6
Working depth of tooth (in.)	0.4	
Transverse pressure angle (deg-min)	22-48	

Adopting the suggested rule, addendum of pinion $= 0.4[0.5 + (2.5)/40] = 0.225$ inch, and addendum of gear $= 0.4 - 0.225 = 0.175$ inch.

With tip circle curvature neglected the maximum

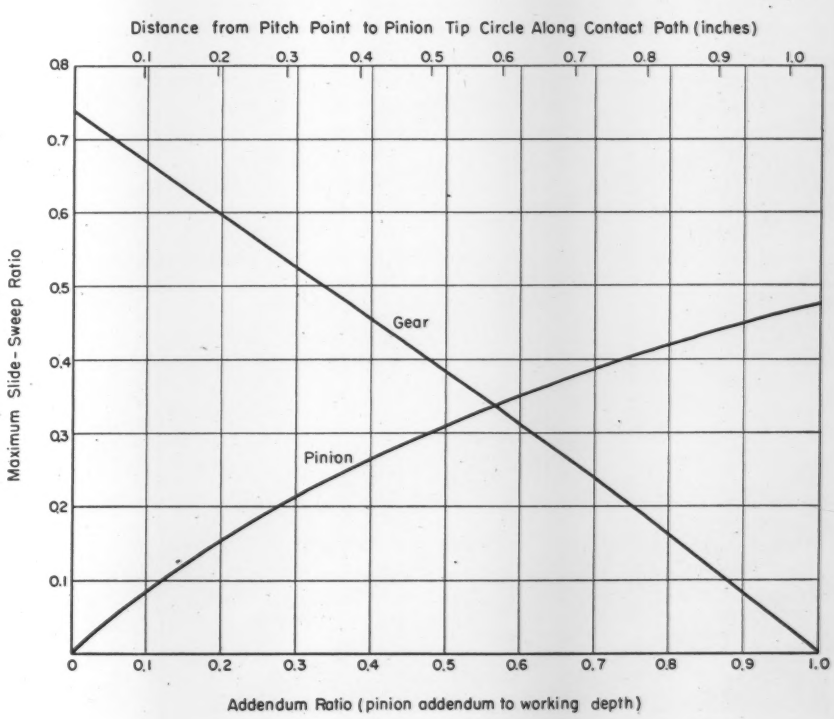


Fig. 3 — Maximum slide-sweep ratios for different addendum designs of typical gear and pinion pair

value of PA for the pinion is 0.225 cosec 22 deg 48 min = 0.58 inch.

The sliding velocity at the tip is therefore about $(\omega_1 + \omega_2)(0.58) = (6000 + 1000)(2\pi)(0.58) =$ 25,500 inch per minute or 2120 fpm.

From Equation 5 the slide-sweep ratio for the pinion is

$$\frac{1 + \dfrac{1000}{6000}}{1 - \dfrac{(PB_1)}{-0.58}}$$

From *Fig.* 2 it may be seen that PB_1 for either gear is the product of its pitch radius and the sine of the pressure angle of engagement. Here $PB_1 =$ (7.6/2) sin 22 deg 48 min = 1.47 inch, and so

$$S_1 = \frac{1.167}{1 - \dfrac{1.47}{-0.58}} = 0.33$$

For the gear the corresponding expression is used except that 1.47 is replaced by 6 times that amount and 0.58 by 0.175 cosec 22 deg 48 min = 0.45.

Then

$$S_2 = \frac{1 + \dfrac{6000}{1000}}{1 - \dfrac{6(1.47)}{-0.45}} = 0.34$$

The slide-sweep ratios at the tips of the teeth of both gears are thus practically equalized. The ratio at the inner limit of working depth is $0.33/(0.33 - 1) = -\frac{1}{2}$.

The normal practice of using equal addendums for pinion and gear would give in this case:

Maximum (AP) = 0.2 cosec 22 deg 48 min = 0.515-inch

Maximum sliding velocity = 2120 (0.515)/(0.58) = 1880 fpm

Maximum slide-sweep ratio (on the gear teeth) =

$$\frac{1 + 6}{1 - [6(1.47)/(-0.515)]} = 0.39$$

The practice, which has had some vogue, of making the pinion with "all-addendum" teeth would almost double the maximum sliding velocity to about 3760 fpm. The maximum slide-sweep ratio (on the pinion teeth) would be

$$\frac{1.167}{1 - \dfrac{1.47}{2(-0.515)}} = 0.48$$

This scheme combines the highest sliding velocity with the highest slide-sweep ratio and is

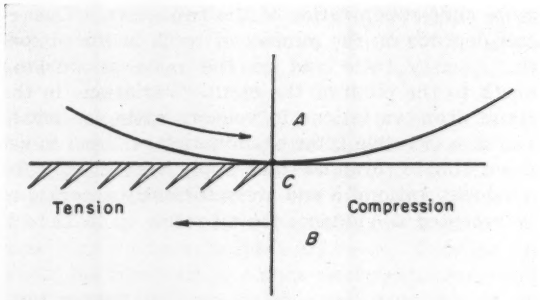


Fig. 4—Above—Sliding of surfaces, showing how cracks may be opened to pressure of lubricant where slide-sweep is negative

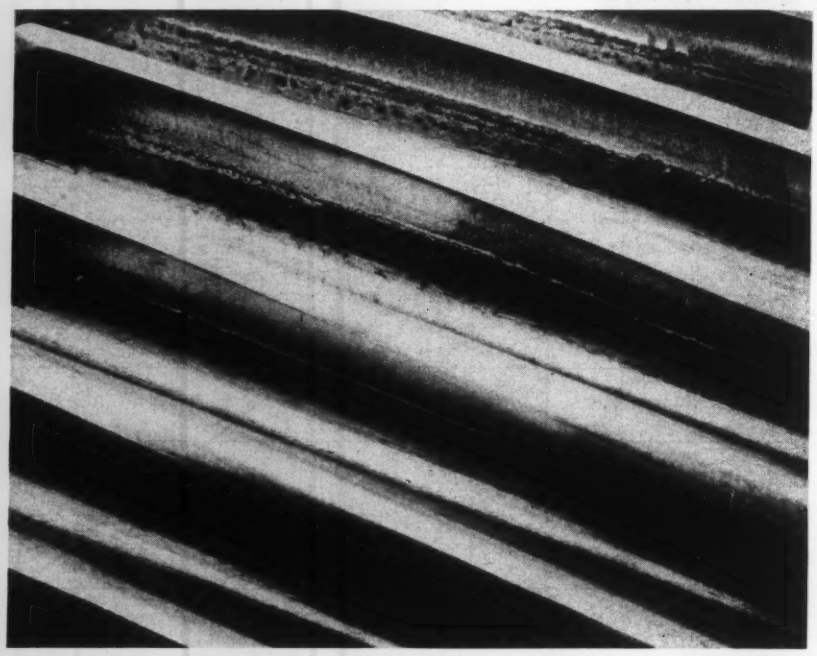


Fig. 5—Left—Gear teeth showing pitting inside the pitch circle, and radial streaks, suggesting incipient scuffing outside the pitch circle

therefore undesirable so far as lubrication is concerned.

Fig. 3 shows the maximum values of the maximum slide-sweep ratio for the pinion of a pair with numbers of teeth, pitch and transverse pressure angle as just discussed but with any desired value of the pinion addendum up to the working depth of the tooth. The maximum value of PQ_1 is thus 0.4 cosec 22 deg 48 min = 1.04. The diagram also gives the maximum slide-sweep ratio of the mating gear. These ratios change in opposite directions for any change in the addendum of the pinion. It shows that one or the other of the gears must have a maximum slide-sweep ratio greater than 0.33 but that by appropriate choice of addendums, neither gear need have a ratio much greater than this.

Pitting of Gear Teeth: Although the causes of pitting of gear teeth are not completely understood, there is a great deal to support the suggestion by Stewart Way* that it is the result of extension of cracks in the material by the trapping of oil in them.

In *Fig.* 4 the upper surface *A* is sliding over the lower one *B* in the direction from left to right and the frictional drag on *B* exerts a tensile stress on the surface of *B* immediately to the left of the contact line at *C*. There is thus a tendency to open the mouths of any cracks that there may be in the part of *B*'s surface that the contact-line is approaching.

These cracks may lie in any direction, but the ones discussed here are those which meet the surface of *B* in lines substantially parallel to the contact line and which extend downward from right to left as shown in *Fig.* 4.

The relative motion of the surfaces induces a hydrodynamic pressure in the oil immediately to the left of *C* and oil is therefore forced into the cracks as *C* approaches them. At the nominal contact line the oil pressure transmitted to the crack may suffice to extend it more deeply into the material of the tooth. Furthermore (or perhaps alternatively) heavy pressure at the nominal contact line may compress the material of *B* so that the mouth of the crack is closed, thus trapping oil within it. Further movement of the contact line tends to move the sealing line of the crack from its mouth towards its root, thus confining the trapped oil to a smaller volume, with the result that the pressure rises and the crack is extended.

Way found evidence to support this suggestion in the fact that although prolonged running of loaded disks with oil could result in pits similar to those which occur in gear teeth, he failed to produce any pits in disks run together without oil.

Further supporting evidence is found in the fact that pitting of spur gears usually begins in the dedendum of the pinion near the pitch cylinder; that is, in the region of negative slide-sweep ratio and also in the region where the whole load is taken by one pair of teeth at any one instant. The nearer the contact line is to the root of the pinion tooth, the smaller the relative radius of curvature of the surfaces and so the higher the surface stress where the whole load is taken by a single pair of teeth.

It must be added that, in severe cases, pitting may occur on parts of tooth profiles where the slide-sweep ratio is positive and where the trapping of oil in cracks cannot occur in the exact manner described. It seems likely therefore that although some pits originate in the manner suggested by Way, that is not the only possible cause of pitting.

In some cases, *Fig.* 5, spur and helical gears have shown signs of overload by pitting in the dedendums and faint streaking (probably incipient scuffing) in the addendums. The fact that mating surfaces had partially failed in entirely different ways was at first surprising, but the difference between their slide-sweep ratios suggested a possible explanation.

* Stewart Way—"Pitting Due to Rolling Contact," *Journal of Applied Mechanics*, Vol. 2, 1935, Pages A-49—A-58.

They Say . . .

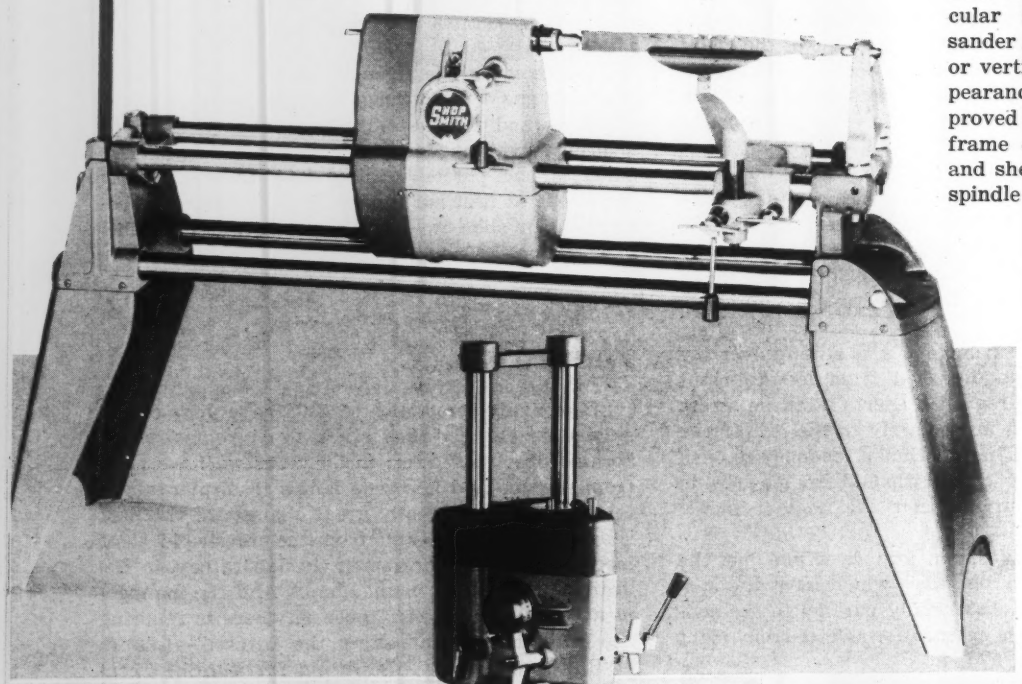
"How many companies of 1903 have gone out of existence—because they stuck to a product which became obsolete? Yes, in 50 years we have gone from wagons and kerosene lamps to airplanes and television . . . the really great changes of the past —as of the future—stem from the creative ideas of men and women working in the laboratory, in the drafting room, and in the shop. And the management that ignores what goes on there is ignoring the real things that affect the future."—LEE A. DUBRIDGE, *president, California Institute of Technology.*

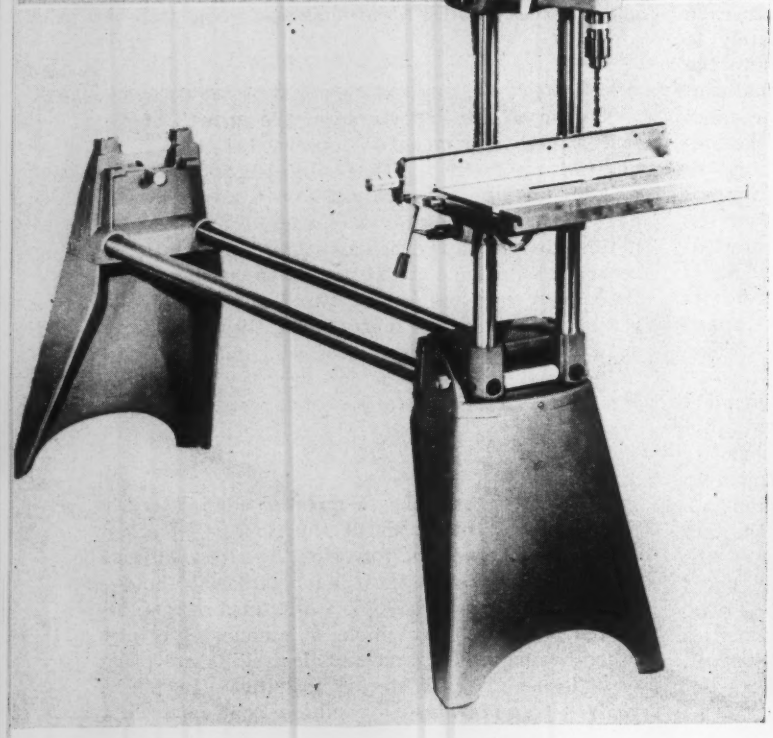
"So far as the importance of the growth of research and development is concerned, I can assure you that my feeling on that subject is so deep that it is not just words. I truly believe that we are engaged in a technological war, where the stakes are nothing less than the preservation of our national security. Furthermore, if we are to continue with the steady and even more rapid advance of our standard of living, we must constantly pound away at more and more basic research and more and more applied research in industry." WALTER WILLIAMS, *under-secretary of commerce.*

"It is . . . a mistake to mix the administrative functions with the scientific functions of good research engineers. The top scientific men should be used for the jobs they are best qualified to hold—that is, the research jobs. Administering a research staff is similar to the administering of any other business staff, and technical skills are often of little use in administering activities.—LESLIE R. GROVES, *vice-president, Remington Rand Inc.*

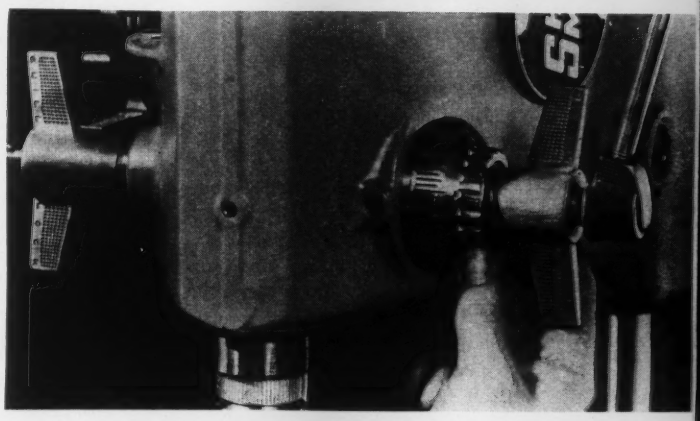
Versatile Home Workshop Tool Redesigned

MANY interesting new design features have been incorporated in the recently announced Mark 5 Shopsmith. Versatility of its predecessor has been retained. As delivered, the machine is ready to be plugged in and used as a 34-inch lathe, 9-inch circular saw, 12-inch disk sander and as a horizontal or vertical drill press. Appearance has been improved by an attractive frame of tubing, castings and sheet-steel. Motor and spindle drive mechanism



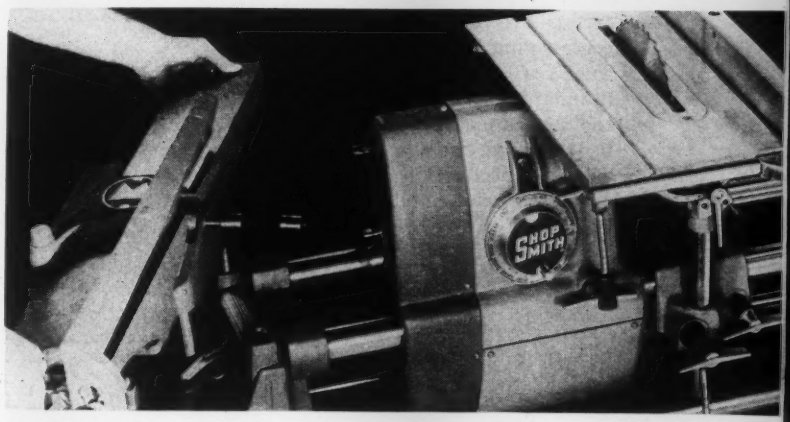


are completely enclosed. Finish is gray and green except for tubular parts and controls which are chrome plated.

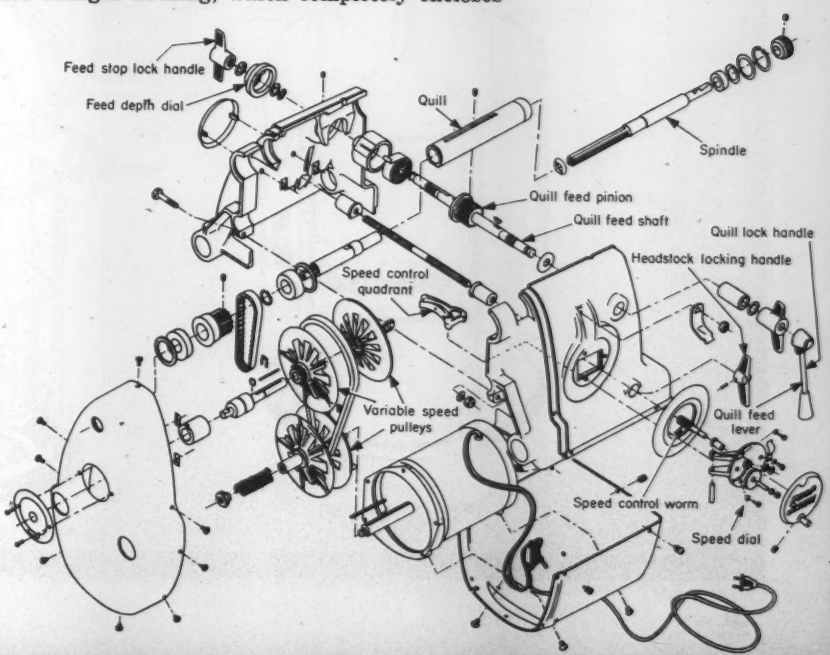


Feed stop at end of quill feed shaft opposite quill lock has calibrated dial for setting depth of hole to be drilled when Shopsmith is used as either horizontal or vertical drill press. With correct depth set on dial, feed stop handle locks setting. Quill feed lever is removable for use at either end of the quill feed shaft.

Auxiliary tools designed for use with the basic machine are mounted by inserting mounting tubes in holes provided. Drive is from auxiliary spindle by flexible coupling. Auxiliary spindle is controlled by Speed-Dial through same range of speeds as main spindle. Jointer is shown being mounted. Other auxiliary tools available are jigsaw and bandsaw.



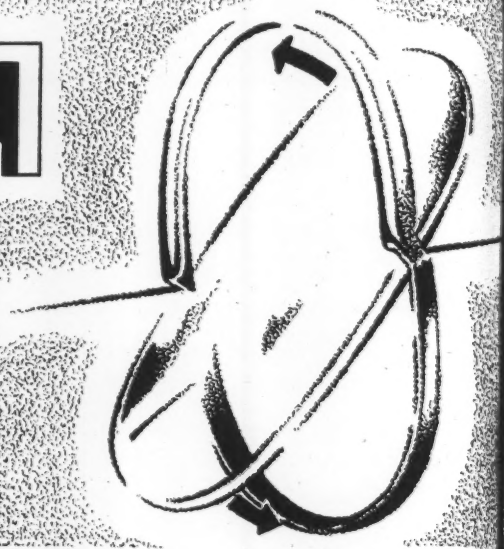
Continuously adjustable spindle speeds, as opposed to constant speed of previous model, are provided by variable-speed pulleys. Speeds are controlled by a large dial on the motor-speed-changer housing, which completely encloses all moving parts except spindle tips for safety. Spindle speeds are variable from 500 to 5200 rpm, but markings on the adjusting dial correspond to operations to be performed such as sanding or sawing. Thus, the operator need not familiarize himself with speeds required for the different operations. On-off switch above the Speed-Dial is protected by wings which prevent accidental starting of the motor but do not interfere with normal operation. Lower wing or T-handle locks the headstock at any position along the tubular ways. Handle above and to the right of the Speed-Dial is the quill feed lock.



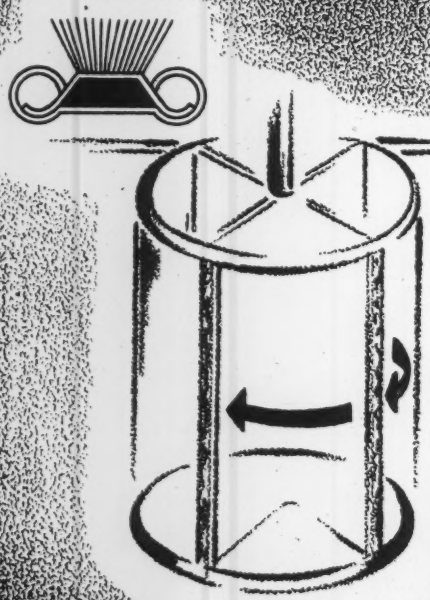
Panel Seals

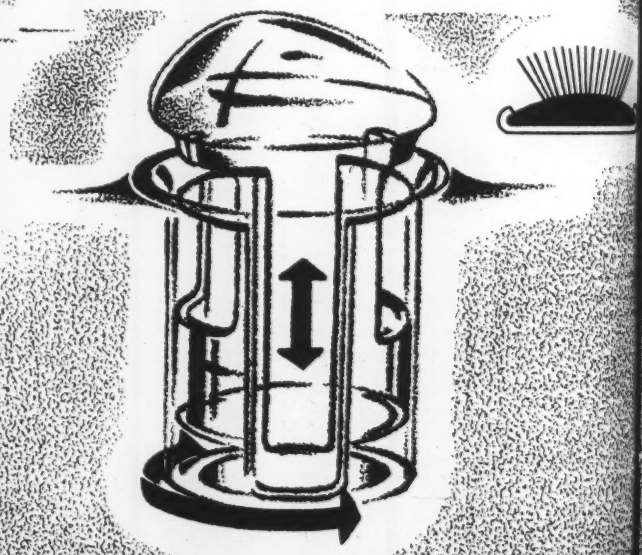
Effective, low-cost sealing media, these panel seals offer a wide variety of functional shapes and sizes to meet application requirements of rotating, sliding or fixed panel assemblies. Composed of rubber, metal and fabric materials, employed either separately or in combination, the various designs provide not only protection from exposure to liquids and gases but often serve as guides or as silencing and anti-rattling devices. Typical types and applications are illustrated in the accompanying views which show some of the designs of the Standard Products Co. Many of the shapes pictured can be readily modified, within the limitations of production techniques, to suit special application conditions.

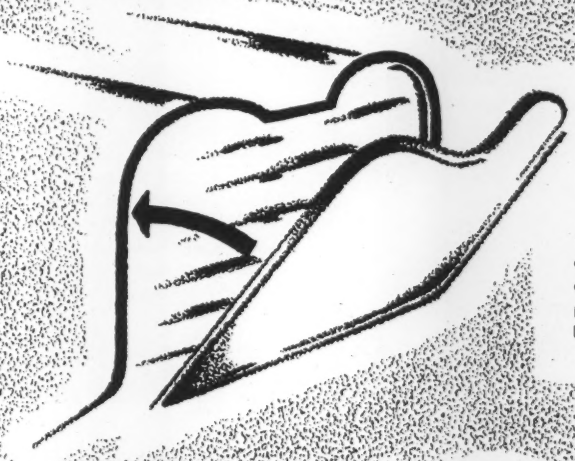
Seal for pivoted panel employs formed rubber shape, bonded or fastened to a backing of metal or other material. Projecting lip gives extra compressibility for improved sealing effectiveness.

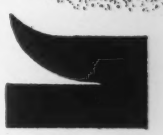


Mobile seal for rotating panels, or sliding and rotating cylinders, has pile fabric set in rubber which is bonded to metal; the combination is produced by roll forming at high speeds. For improved appearance, stainless steel trim beads may be added on either side of the seal.



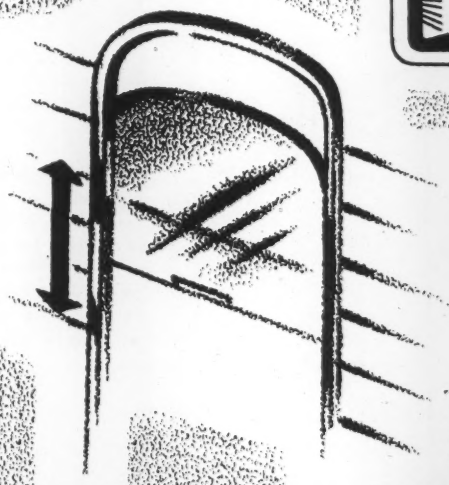




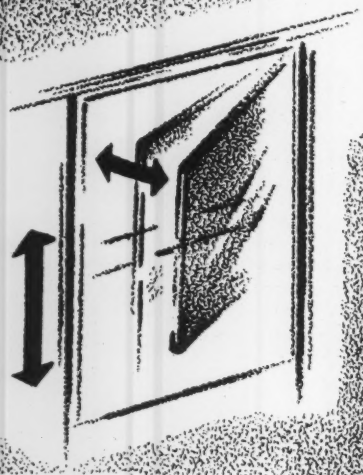


Rubber lip seal for hinged panels of uniform or irregular shape has special lip shape which compresses when panel is closed. Lip design provides added resilence and acts to shed liquids at the joint.

Multiple seal for fixed position panel uses all-rubber construction. Modification of the shape design offers flexibility in meeting different, but similar, application requirements. In the application shown, the seal is employed as a glass setting gasket with the lip serving to cover up a metal panel opening in which the gasket fits.

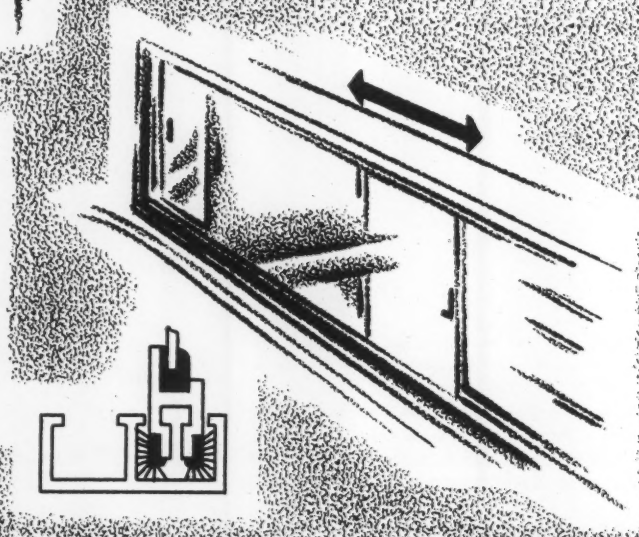


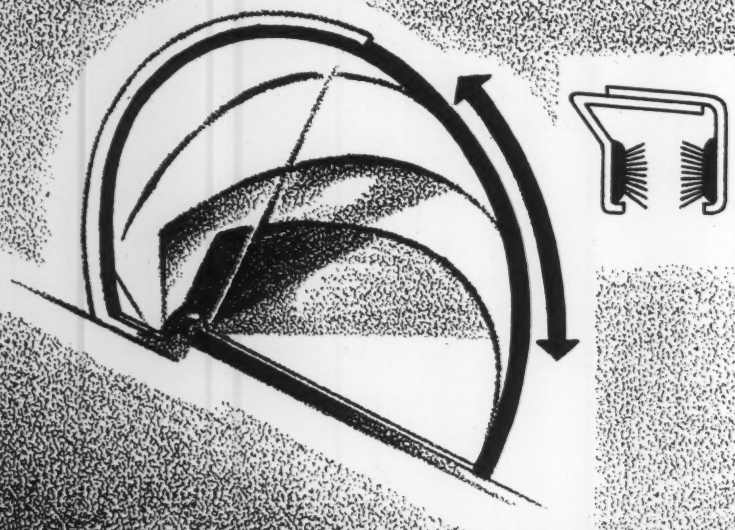
Sliding panel seal is made of pile fabric with a backing of rubber bonded to metal. Although known as a "glass run channel," the seal can be used with any type of panel conforming to the shape of the opening and is available with either rigid or flexible metal cores in a variety of shapes and sizes



Two-way seal employs special extruded rubber shape to seal panel for both sliding and swinging actions. Hump on one leg is an attaching dovetail. Extruded shape may be electrostatically flocked or covered with cloth as required for proper sliding action.

Mobile seal for sliding panels uses pile fabric and rubber, bonded to metal and moving in a metal frame. Serving primarily as weatherstripping for exposed panels, the seal also can be utilized to minimize rattling. In similar applications, a U-shaped channel with outer pile fabric could be substituted for two weatherstrips.

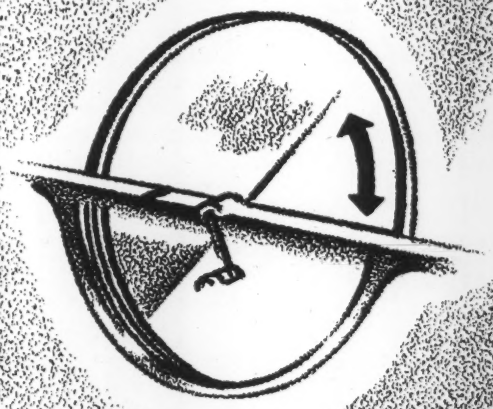


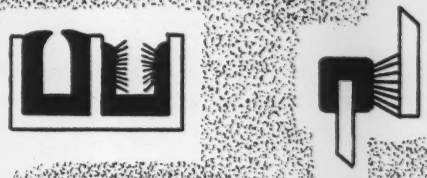


Special variety of glass run channel serves as both seal and guide for irregular-shaped pivoted panels. Seal construction has pile fabric bonded to rubber and metal in a formed stainless frame. The application shown depicts a weatherstrip - and - molding assembly now used for quarter-windows on automobiles.

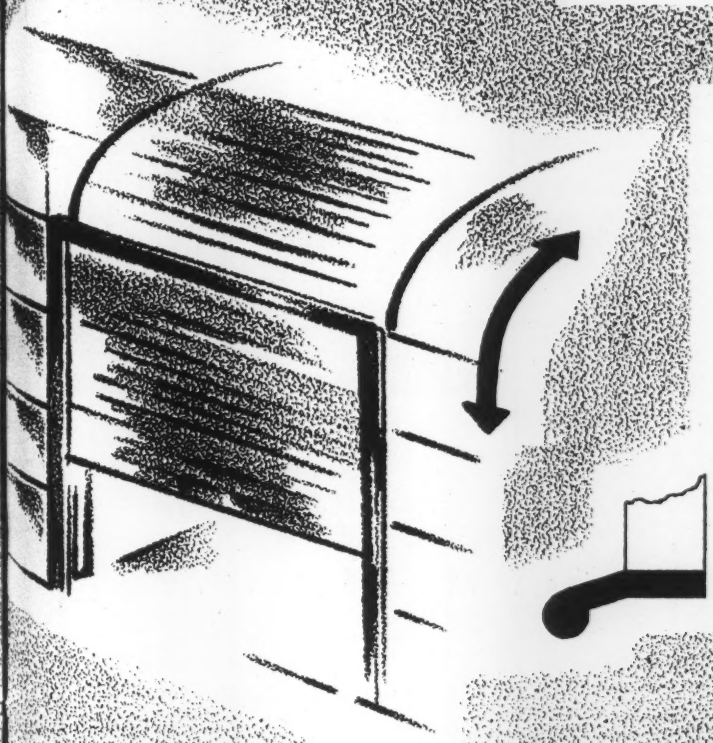
PANEL SEALS

DESIGN DETAILS

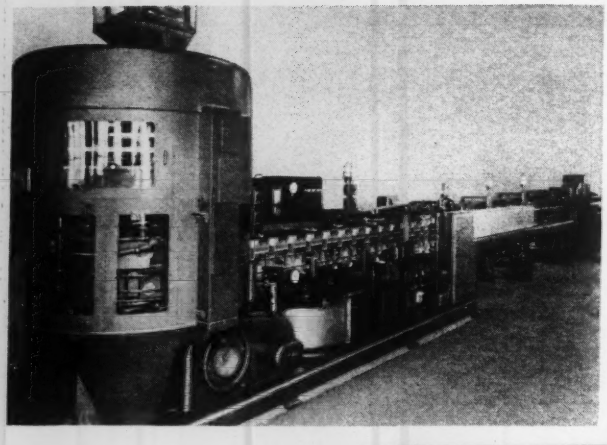




Double panel seal serves as a combination seal and guide for two semicircular panels, one fixed and the other rotating. Fixed panel fits into converging rubber shape bonded to metal in one slot of the double channel. Other slot of channel has pile fabric and rubber seal to accommodate rotating panel. Auxiliary seal of rubber and metal with a pile fabric side extension serves as weatherstrip for panel to panel sealing. This latter seal illustrates the use of a channel to press onto a panel; the pile fabric on the outside of one leg permits the panel to slide on another surface.



Sliding or flexible "door" seal offers effective weatherstrip for exposure under severe icing conditions and can withstand extreme flexing. Long lip may be positioned on either the inside or outside of the panel, depending on which arrangement gives a better seal. For the panel sides, sealing can be accomplished with a mobile seal of pile fabric, rubber and metal.



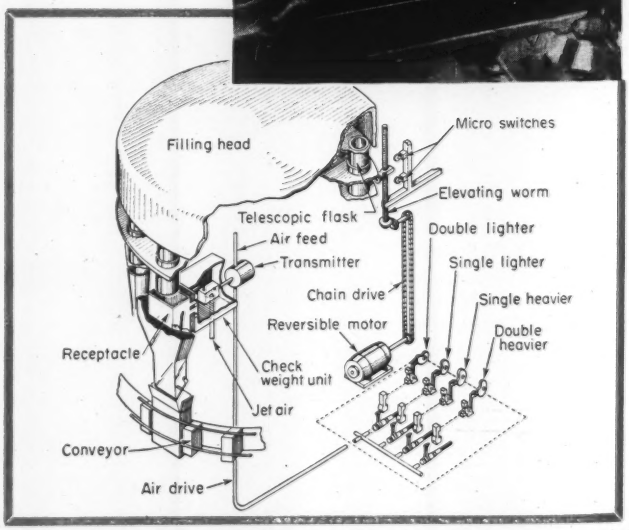
AUTOMATIC compensation for density variations in products such as soap powder in the Velocitron Packager is said to reduce package weight variation by at least one-half. Six operations are performed on the Pneumatic Scale Corp. machine at speeds to 300 cartons per minute: (1) carton blank feeding, (2) setting up of the carton in continuously moving pockets, (3) sealing bottom flaps, (4) measuring the product by volume, (5) depositing the fill load, and (6) glue-sealing the carton top flaps. Volume of carton fill is measured by 12 adjustable flasks mounted on a turret which rotates in synchronization with the carton pockets as they travel in a semicircle around the end of the machine. A volume adjusting device changes volume of all 12 flasks simultaneously on signal from a check weigher to compensate for density variations.

CONTEMPORARY DESIGN

High-Speed Packager Weighs Automatically

A weighing head is mounted directly below one of the 12 measuring flasks. Product is discharged from the flask into a receptacle where it is quickly weighed and deposited into the bottom-sealed carton below. The other 11 flasks discharge independently of the check-weighing operation. The receptacle which receives the fill load to be check-weighed is rigidly mounted to a stiff cantilever assembly of parallel spring bars. Deflection is very small, in the order of 0.002 to 0.003-inch per ounce. Damping apparatus absorbs vibration. Position of the deflected receptacle measures the exact weight of the goods by the commonly used air-gage principle. Change in the deflected position produces changes in air pressure of approximately 1 psi for every 1/16-ounce variation in receptacle content weight. These varying pressures are fed as a signal to the volume adjustment mechanism.

When the checked load varies from predetermined allowable limits, automatic correction of all flask volumes occurs during the next revolution of the turret. One turret cycle is required for check weighing and another for correction. Thus, the complete operation occurs once for every 24 cartons, or approximately once every 5 seconds. A reversible motor adjusts flask volume. Length of time the motor runs governs amount of volume correction, and is controlled by four switches corresponding to two equal increments of overweight and two of underweight. Length of time that switches are "on" is controlled by timing cams. For average weight variations, the "single heavier" and "single lighter" switches are sufficient; when density fluctuation is high, the motor is run for a longer period by the "double" switches.

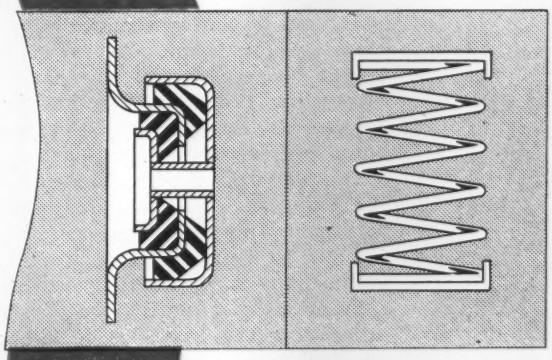


Vibration and Shock Isolators

How to select and apply mountings for control of

- **VIBRATION**
- **NOISE**
- **SHOCK**

By Charles E. Crede
Chief Engineer
The Barry Corp.
Watertown, Mass.



Design methods for Selecting and Applying . . .

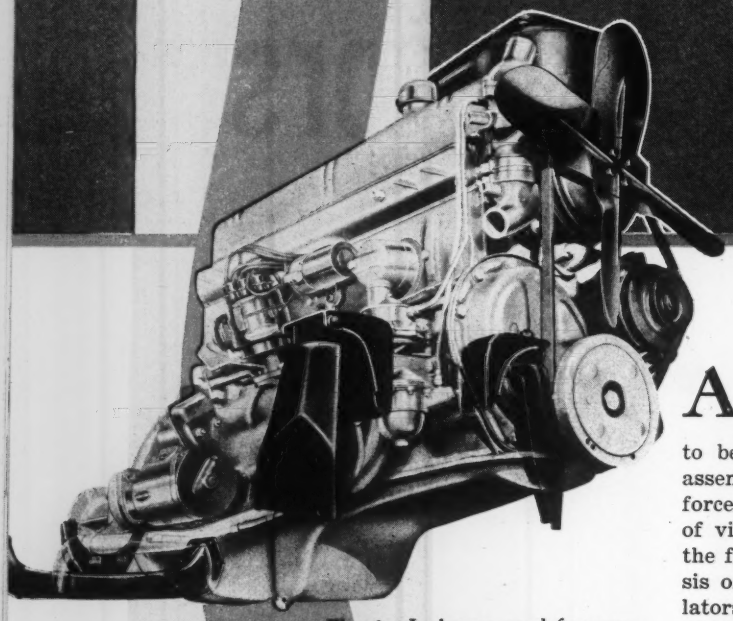
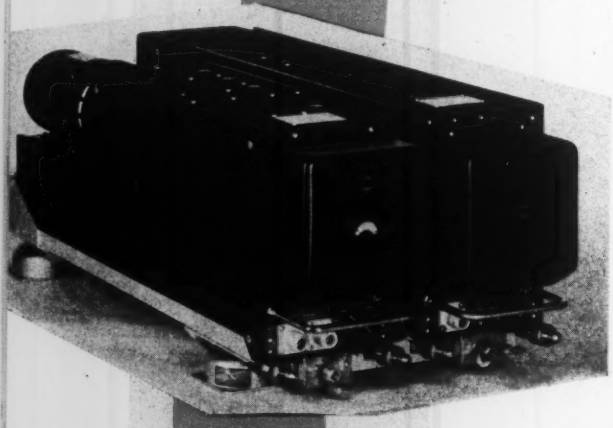


Fig. 1—Isolators used for controlling both dynamic forces and motion, in this case between an engine and an automobile chassis

Fig. 2—Isolators used in airborne electronic equipment for protection of equipment from airframe vibration



AN ISOLATOR may be described as a load-supporting resilient element having controlled elasticity and damping, and adapted to be integrated into a mechanical or structural assembly. Isolators are used to control dynamic forces and motion. A typical example of the use of vibration isolators to reduce the magnitude of the force transmitted from the engine to the chassis of an automobile is illustrated in *Fig.* 1. Isolators may also be used to reduce the motion experienced by equipment that is supported by a structure having significant vibration. Such an application of isolators to airborne electronic equipment for the purpose of protecting the equipment from the vibration of the airframe is shown in *Fig.* 2.

Natural Frequency: The function of an isolator may be best understood by first reducing it to its simplest form, as illustrated in *Fig.* 3. The system of *Fig.* 3 includes a rigid mass m supported by a massless spring k and constrained by guides to move only in vertical translation without rotation about a vertical axis. A viscous damper c is arranged in parallel with the spring between the support and the mass. The mounted equipment is simulated by the mass while the spring and damper taken together simulate the elasticity and viscosity of the conventional isolator. The system shown in *Fig.* 3 is said to be a single-degree-of-freedom system because its configuration at any time may be specified by a single co-ordinate; i.e., by the height of the mass m with respect to the fixed support.

Isolation is attained primarily by maintaining proper frequency relations. The characteristics of the isolator include its natural frequency, or

. . . Vibration and Shock Isolators

more properly, the natural frequency of the system consisting of isolator and mounted equipment. In general, a system has a natural frequency for each degree of freedom; the single-degree-of-freedom system illustrated in *Fig.* 3 thus has one natural frequency. The natural frequency may be defined as the number of cycles of vertical oscillation that the system will carry out in unit time if displaced from its equilibrium and permitted to vibrate freely. The expression for the damped natural frequency q_n of the system illustrated in *Fig.* 3, expressed in cycles per second, is

$$q_n = \frac{1}{2\pi}\sqrt{\frac{kg}{W}\left[1 - \left(\frac{c}{c_c}\right)^2\right]} \quad \ldots\ldots\ldots\ldots (1)$$

where k = stiffness of the spring, pounds per inch; W = weight of the mounted equipment, pounds; g = acceleration due to gravity, inches per second per second; c = damping coefficient, pounds per inch per second; and c_c = value of c for which the damping is critical. A critically damped system returns without oscillation to equilibrium if displaced; it has no natural frequency of oscillation, as indicated by the substitution of $c = c_c$ in Equation 1.

Except in special circumstances, the value of the damping coefficient is relatively small. The influence of damping on the natural frequency may then be neglected. Setting the damping coefficient c equal to zero, the system becomes an undamped single-degree-of-freedom system, and the undamped natural frequency is given by

$$f_n = \frac{1}{2\pi}\sqrt{\frac{kg}{W}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This expression is sufficiently accurate for calculating the actual natural frequency in almost every instance. Its use is rigorously correct in analyses set forth later for calculating the effectiveness of isolators in isolating vibration.

Fig. 3—Simplest form of an isolator, a spring, k, and viscous damper, c, supporting the equipment mass, m

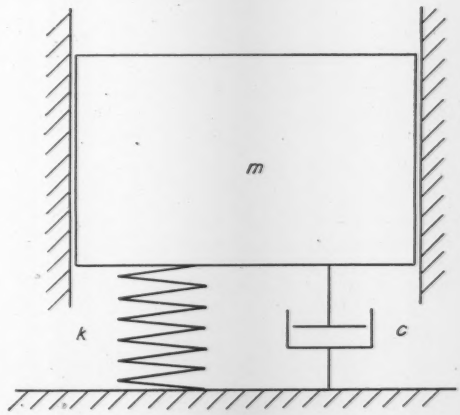


FIGURE CREDITS

Figs. 1, 19, 22—Reference 1; *Fig.* 2—Collins Radio Co.; *Fig.* 5—General Electric Co.; *Figs.* 6, 11, 23, 24—C. E. Crede and J. P. Walsh—"Design of Vibration Isolating Bases for Machinery," *Trans. ASME*, March, 1947 (*Jour. App. Mech.*, Vol. 14, No. 1); *Fig.* 18—Reference 3; *Figs.* 15, 20—R. D. Mindlin—"Dynamics of Packaged Cushioning," *Bell System Technical Jour.*, Vol. 24, Nos. 3-4, July-October, 1945.

Assume now that the constraints on the mass in *Fig.* 3 are such as to permit the mass to rotate with respect to a vertical line through its center of gravity, but that there are constraints to prevent translatory movement in the vertical as well as the horizontal direction. Such a system is thus a single-degree-of-freedom system in that the only co-ordinate required to define the position of the system is the angular orientation of the mass when viewed from above. The natural frequency of the system in rotation about a vertical axis, in cycles per second, is

$$f_r = \frac{1}{2\pi}\sqrt{\frac{k_r}{I}} \qquad (3)$$

where k_r = stiffness of the spring, inch-pounds of moment per radian of angular displacement about the vertical axis; and I = mass moment of inertia of the supported mass about a vertical axis through its center of gravity, pound-inch-seconds^2.

VIBRATION ISOLATION

Single Degree of Freedom: In steady-state vibration, the excitation may be a varying force acting upon the supported body or an oscillating motion of the support for the system. The function of the isolators in the first instance is to reduce the magnitude of the force transmitted to the support; in the second instance, the function is to reduce the magnitude of the motion transmitted to the mounted equipment. Effectiveness of the isolators in bringing about such a reduction is indicated by the transmissibility of the system. In the force-excited system, transmissibility is the ratio of the force experienced by the support to the force acting upon the mounted body. Similarly, transmissibility in the motion-excited system is the ratio of the displacement amplitude of the mounted body to the displacement amplitude of its support. The expression for the transmissibility of the damped single-degree-of-freedom system in *Fig.* 3 is

$$T = \sqrt{\frac{1 + \left(2\frac{f}{f_n}\frac{c}{c_c}\right)^2}{\left(1 - \frac{f^2}{f_n^2}\right)^2 + \left(2\frac{f}{f_n}\frac{c}{c_c}\right)^2}} \qquad (4)$$

where T = transmissibility, a dimensionless ratio; and f = frequency at which the exciting force or motion is applied. The latter is often referred to as the forcing frequency. The same expression for transmissibility applies to both force-excited and motion-excited systems. Curves showing transmissibility as a function of the ratio of forcing to natural frequency are shown in *Fig.* 4 for various values of the damping ratio c/c_c.

EXAMPLE 1: Assume that the equipment shown in *Fig.* 2 weighs 50 pounds, that the isolators are undamped, and that each isolator has a stiffness in the vertical direction of 100 pounds per inch of deflection. The support for the system vibrates in a vertical direction with a displacement amplitude of 0.05-inch at a freequency of 40 cycles per second. It is desired to determine the vibration amplitude of the mounted equipment. Substituting in Equation 2, $k = 4(100)$, $g = 386$, and $W = 50$, gives the natural frequency of the system in vertical translation, 8.85 cycles per second. The applicable frequency ratio is 40 divided by 8.85, or 4.52. Entering *Fig.* 4 at a frequency ratio of 4.52 and using the curve for zero damping gives a value of transmissibility of 0.05, read from the vertical scale. The displacement amplitude of the mounted eequipment is then the product of the transmissibility and the amplitude of the support: 0.05(0.05) = 0.0025-inch displacement amplitude for the mounted equipment.

EXAMPLE 2: An application of a vibration isolator which functions in a rotational mode is the electric motor mounting illustrated in *Fig.* 5. This motor is mounted by means of rubber rings encircling the end-bell hubs, the rubber rings being strained in shear during rotational displacement. Shear stiffness is the term k_r in Equation 3. It is desired to determine the transmissibility of the ring-type isolators. Since the rotor and stator are free to move independently in rotation about the shaft axis, only the stator is considered in determining the inertia load on the isolators for angular vibration about the shaft axis. Weight of the stator is 30 pounds, and its radius of gyration with respect to the shaft axis is 3 inches. Moment of inertia I of the stator about the shaft axis is thus calculated to be 0.70-pound-inch-second^2. It is determined by static test that a torque of 800 pound-inches is required to rotate the stator 1 degree about the shaft axis. Multiplying this measured stiffness by 57.3 degrees per radian gives a value of k_r = 45,800 pound-inches per radian. Substitution of these values for k_r and I in Equation 3 gives a natural frequency in rotation of 40.7 cycles per second. If the design of the motor is such that the torque impulses are applied to the stator at a frequency of 120 cycles per second, the applicable frequency ratio is 120 divided by 40.7, or 2.95. From *Fig.* 4 at a frequency ratio of 2.95, a transmissibility of 0.13 is read from the vertical scale and the curve for zero damping. This transmissibility, when multiplied by the magnitude of the torque impulses, will give the magnitude of the torque impulses transmitted to the support of the motor.

The transmissibility curves shown in *Fig.* 4 for the single-degree-of-freedom system show a very large transmissibility when the forcing and natural frequencies are equal. This is a condition of resonance. Large values of transmissibility, if the system is motion-excited, indicate a relatively great motion of the mounted equipment. Somewhat less rigorously, a large value of transmissibility in a force-excited system also indicates that the motion of the mounted equipment is relatively

great. Even though *Fig.* 4 refers to steady-state conditions and the indicated transmissibility does not materialize if the resonance exists only momentarily, there is a pronounced tendency toward an amplitude increase if forcing and natural frequencies become equal for only a few cycles of vibration. This condition is often encountered during the starting and stopping of a machine when the operating frequency momentarily equals the natural frequency of the isolators. If this condition is likely to occur, it is desirable that the isolators embody appreciable damping.

It is evident from *Fig.* 4 that the addition of damping to the system decreases the transmissibility at resonance and increases the transmissibility in the isolating range of forcing frequencies. The physical significance of the damping coefficient for steady-state vibration may be estimated from *Fig.* 4 from values of transmissibility at resonance for the respective curves. For relatively small values of damping, the damping ratio c/c_c is approximately equal to one-half the reciprocal of the maximum transmissibility. For example, in a system whose maximum transmissibility at resonance is 5, the corresponding damping ratio is $\frac{1}{2}(1/5) = 0.1$, as indicated in *Fig.* 4.

The concept of static deflection often is used to define the characteristics of an isolator. Static deflection is the deflection of the isolator under the static or deadweight load of the mounted equipment. Referring to Equation 2 and substituting $g = 386$, $W/k = \delta_{st}$, the following expression is

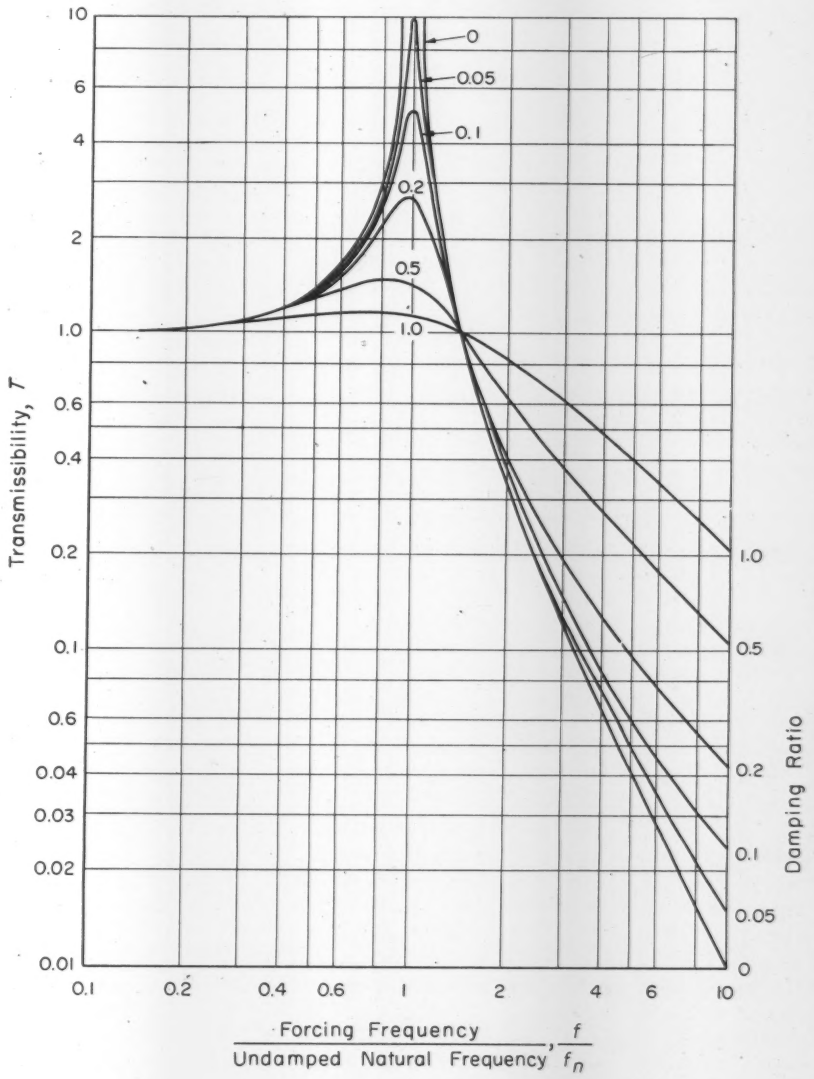


Fig. 4 — Transmissibility — ratio of displacement amplitude of the mounted body to that of its support —for various frequency and damping ratios of a single-degree-of-freedom system

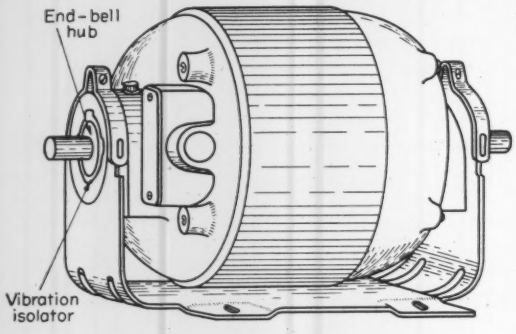


Fig. 5—Vibration isolator for electric motor, which functions in a rotational mode

obtained for natural frequency in terms of static deflection:

$$f_n = 3.13\sqrt{\frac{1}{\delta_{st}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where f_n = natural frequency, cycles per second; and δ_{st} = static deflection, inches. A graphic portrayal of Equation 5 is given in *Fig.* 6. It thus appears possible to determine the natural frequency of a single-degree-of-freedom system by measuring only the static deflection. This is true with certain qualifications. In the first place, the spring must be linear—its force-deflection curve must be a straight line. In the second place, the resilient material must have the same type of elasticity under both static and dynamic conditions. Metallic springs generally meet this latter requirement, but many organic materials used in isolators do not. The dynamic modulus of elasticity of these materials appears to be higher than the static modulus; the natural frequency of the isolator is thus somewhat greater than that calculated on the basis of static deflection alone. Dynamic stiffness may be obtained indirectly by determining the natural frequency when the isolator is vibrated with a known load and calculating the dynamic stiffness from Equation 2. The various organic materials have certain peculiarities with respect to dynamic stiffness which will be discussed later in connection with the specific materials.

Many Degrees of Freedom: The single-degree-of-freedom system shown in *Fig.* 3 is adequate for illustrating the fundamental principles of vibration isolation, but is a great oversimplification insofar as many practical applications are concerned. It is not generally feasible to use guides for constraining the motion of mounted machines. Additionally, constraint would not be desirable in many applications because the horizontal component of the force generated by the machine, or the horizontal component of the motion of the support, would be transmitted directly through the rigid guides. There would then be no isolation of the horizontal force or motion. To obtain proper vibration isolation, it is generally necessary to allow the mounted machine freedom to move in all directions according to its natural tendency under existing force and motion conditions.

Consider now a symmetrical body supported by identical springs at each of the eight corners and unrestrained by rigid guides, as shown in *Fig.* 7*a*. This is a six-degree-of-freedom system. The mass is free to move vertically and horizontally in the plane of the paper and rotationally with respect to an axis normal to the paper. Furthermore, when viewed in a vertical plane normal to the plane of the paper, it has similar freedom of motion horizontally and rotationally. When viewed from above, it is free to rotate with respect to a vertical axis. The system has a natural frequency in each of these six natural modes of vibration; three in translatory modes along three mutually perpendicular axes and three in rotational modes with respect to the same three mutually perpendicular axes. Any vibration may be resolved into components in these modes.

When the resilient supports are located unsymmetrically with respect to the center-of-gravity of the body, certain translatory and rotational modes of vibration may become coupled. A coupled mode of vibration may comprise, for example, a translatory component and a rotational component about an axis through the center of gravity of the body. This may appear as rotational motion about an axis which does not pass through the center of gravity. If the supports are placed at the bottom, as shown in *Fig.* 7*b*, the vibration in the horizontal translatory mode degenerates to a coupled mode in which the mounted body vibrates in rotation

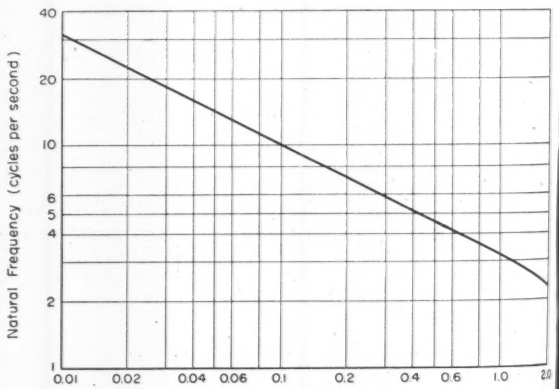


Fig. 6—Determination of natural frequency of a single-degree-of-freedom system by means of static deflection, a method which is valid under certain conditions

with respect to an axis below the center of gravity of the body. Furthermore, the rotational vibration degenerates to coupled vibration with respect to an axis above the center of gravity.

A body on resilient supports may vibrate in a natural mode simultaneously with, but independently of, its vibration in other natural modes if the respective modes are decoupled. If the modes are coupled, vibration in one coupled mode cannot occur independently of vibration in another mode coupled thereto. Coupling depends upon the stiffness and location of the resilient supports, and on the mass distribution of the supported body. The following test may be applied to a body on flexible supports to determine whether translatory vibration in a particular direction is decoupled. Apply a steady force to the body through its center of gravity and in the specified direction. If the body moves in the direction of the force without rotation, translatory vibration in the direction of the force is decoupled from vibration in other modes. The meaning of this test can be illustrated by reference to *Fig. 7b*. When a vertical force is applied to the body along a line extending through the center of gravity, the body moves vertically without rotation. The vertical translatory mode is thus decoupled. A horizontal force through the center of gravity, however, not only displaces the body horizontally but causes it to rotate about an axis below the body. The horizontal and rotational modes are thus coupled and vibration in one of these modes cannot exist independently of vibration in the other mode.

Simplicity of the analysis of a vibrating system having only decoupled modes of vibration, and the complexity of a corresponding analysis including

Fig. 7 — Below—A symmetrical body supported by identical springs at each of the eight corners, constituting a six-degree-of-freedom system, *a*. When supports are located unsymmetrically with respect to the center of gravity, *b*, certain modes of vibration may become coupled

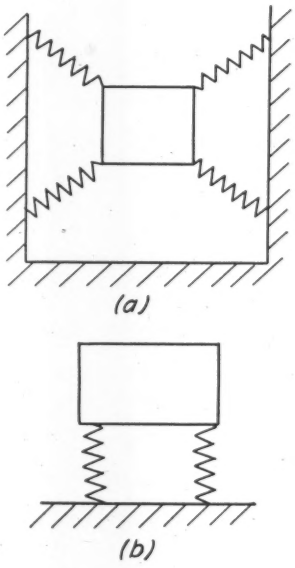
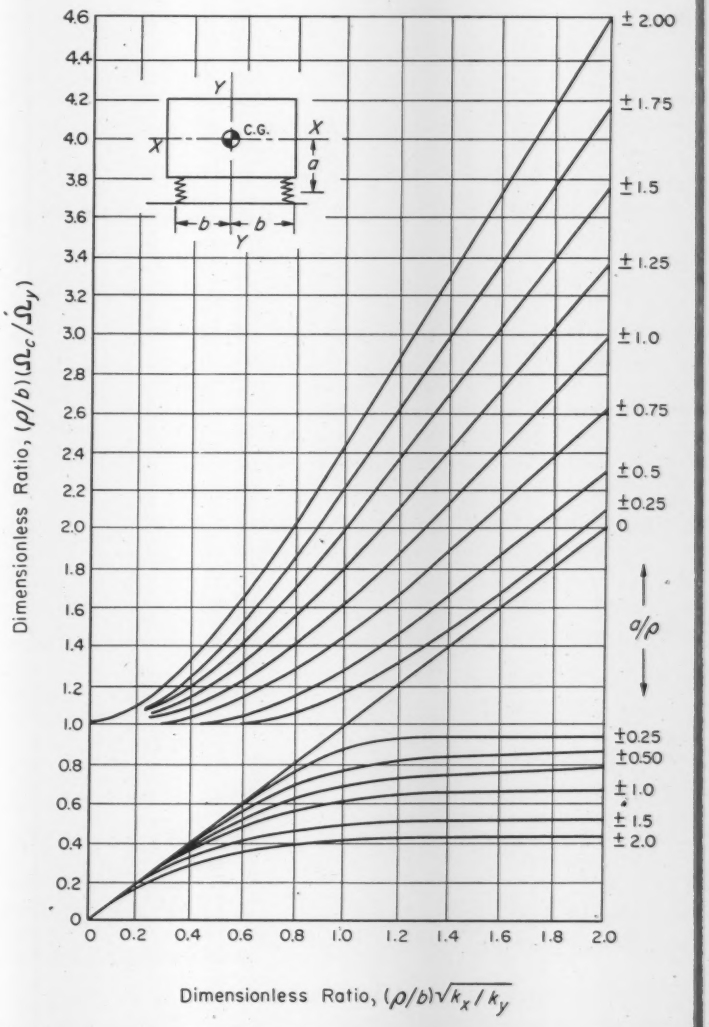


Fig. 8—Right—Chart for determining natural frequencies for an often - used isolator mounting method



coupled modes, has encouraged concentration on the simple approach. This condition has misled many design engineers by de-emphasizing the importance of coupled modes. Consideration of these coupled modes is necessary in the design of the common mounting arrangement in *Fig. 7b*. Calculation of the transmissibility for such a system becomes somewhat involved,[1] but for most practical purposes it is not necessary to delve into the analysis so deeply.

By analogy with the single-degree-of-freedom system illustrated in *Fig.* 3, it may be assumed that satisfactory vibration isolation will occur in most applications if all natural frequencies of the mounting system are maintained substantially lower than the forcing frequency. Determination of the natural frequencies of the system illustrated in *Fig.* 8 is relatively straightforward. In addition to the weight of the mounted equipment and the stiffnesses of the isolators in the vertical direction, it is necessary to know the radius of gyration or moment of inertia of the mounted equipment, the stiffnesses of the isolators in horizontal directions, the spacing between isolators, and the height of the center of gravity of the mounted equiment. If these physical parameters are known, the several natural frequencies may be determined from *Fig.* 8.

Two natural frequencies are obtainable from *Fig.* 8. These are the two coupled or degenerate modes referred to previously in connection with *Fig. 7b*. Each of the coupled modes of vibration embodies horizontal and rotational components. It is first necessary to assume that the vertical translatory mode of vibration is decoupled. This can be achieved by assigning stiffnesses to the respective isolators in proportion to the deadweight load carried by each isolator. The vertical natural frequency can then be calculated readily from Equation 2. This vertical natural frequency thus becomes a reference frequency, and the two coupled natural frequencies are determined with reference to the vertical natural frequency.

EXAMPLE 3: To illustrate the application of *Fig.* 8 in determining the natural frequencies of a system having coupled modes of vibration, *Fig.* 9 is an elevation view of one side of the mounted equipment illustrated in *Fig.* 2. The natural frequency of this system in vertical translatory vibration was calculated previously. Pertinent dimensions are included in *Fig.* 9 and ratio k_x/k_y of horizontal to vertical stiffness of the isolators is taken as ½. Assuming the mass of the mounted equipment to be uniformly distributed throughout its volume, the radius of gyration about an axis through the center of gravity and perpendicular to the paper is

$$\rho = \sqrt{\frac{d^2 + e^2}{12}} = \sqrt{\frac{100 + 49}{12}} = 3.52 \text{ inches}$$

From the dimensions in *Fig.* 9 and the nomenclature in *Fig.* 8, it follows that $a = 4.25$, $b = 4$, $a/\rho = 4.25/3.52 = 1.21$, and $\rho/b = 3.52/4 = 0.88$. The appropriate numerical value to use on the horizontal scale of *Fig.* 8 is now calculated as

$$\frac{\rho}{b}\sqrt{\frac{k_x}{k_y}} = 0.88\sqrt{\frac{1}{2}} = 0.62$$

Entering *Fig.* 8 at a value of 0.62 on the horizontal scale and moving vertically to the intersections with the two curves marked $a/\rho = 1.21$, read values of 0.48 and 1.32 from the vertical scale at the left-hand margin. Dividing these values by $\rho/b = 0.88$, the ratios Ω_c/Ω_y of coupled natural frequencies to vertical natural frequency are determined as 0.55 and 1.50. Multiplying these ratios by the previously determined vertical natural frequency of 8.85 cycles per second gives natural frequencies of 4.9 and 11.7 cycles per second in the coupled horizontal and rotational modes of vibration. To avoid resonances and insure a low transmissibility, the forcing frequency should be substantially greater than 11.7 cycles per second.

In general, mounting systems having the isolators below the center of gravity of the mounted equipment have at least one natural frequency greater than the vertical natural frequency. Consequently, if all natural frequencies are to be maintained below a minimum established by the forcing frequency, vertical natural frequency must be lower than would be necessary if the coupled modes of vibration were not considered. This increases the static deflection of the isolators and introduces

[1]References are tabulated at end of article.

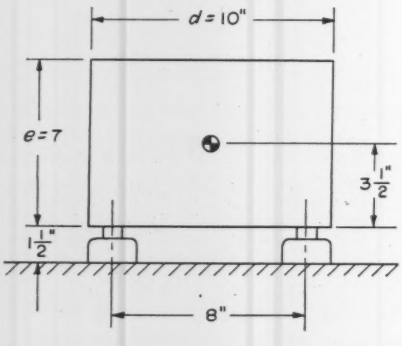
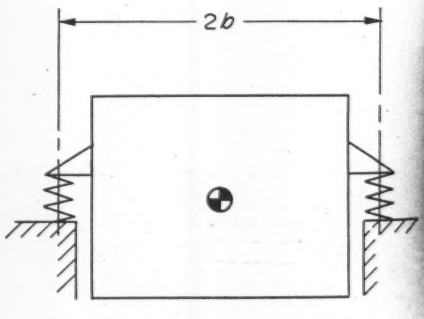


Fig. 9—Left — Elevation of typical equipment (Example 3)

Fig. 10 — Right — Method of decoupling coupled modes of vibration by locating isolators in a horizontal plane through the center of gravity

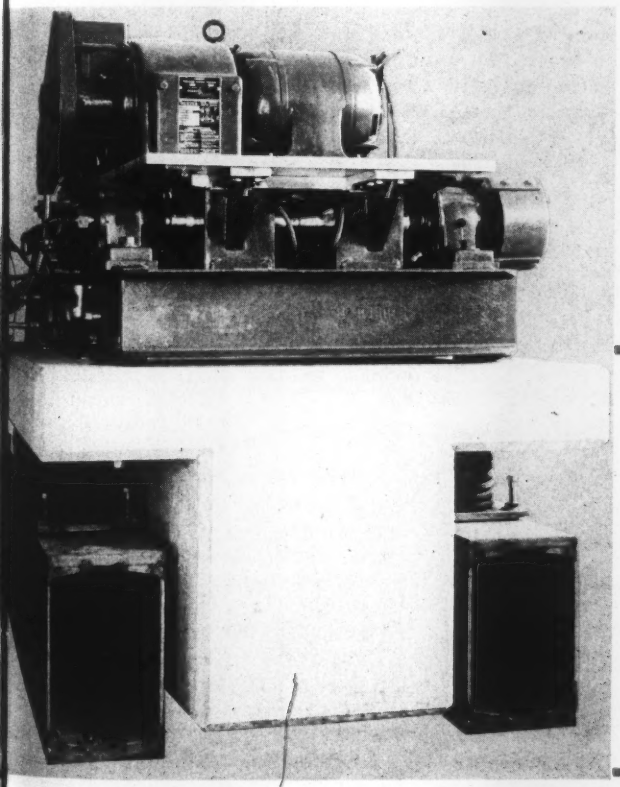


a tendency toward instability in the mounting system. This tendency often can be alleviated by arranging the system to decouple the natural modes of vibration.

One method of attaining decoupling is to locate the isolators in a horizontal plane that passes through the center of gravity of the mounted equipment. Such an arrangement is illustrated schematically in *Fig.* 10. The dimension a is equal to zero, and the natural frequencies in horizontal translation and in rotation may be determined from the inclined and horizontal curves, respectively, in *Fig.* 8 for the ratio $a/\rho = 0$. The rotational and vertical natural frequencies become equal in this arrangement if the spacing between isolators is twice the radius of gyration of the equipment; i.e., if $\rho = b$. The natural frequency in the horizontal translatory mode can be made equal to the vertical translatory and rotational natural frequencies by introducing the additional requirement that the isolators have equal vertical and horizontal stiffnesses. This condition is defined by the intersection of the two curves $a/\rho = 0$ in *Fig.* 8. An application of this principle is illustrated in *Fig.* 11, where the isolators are in the same horizontal plane as the center of gravity of the block and machine combination. The T-shaped concrete block makes it possible to have the distance between isolators equal to twice the radius of gyration of the mounted combination along both horizontal axes, a result which is otherwise unattainable unless the height of the mounted equipment substantially exceeds its maximum width.

Another method of decoupling modes of vibration is to incline the isolators, as illustrated in *Fig.* 12. Control of the various physical parameters of the system becomes quite critical with this arrangement if true decoupling is to be attained. This is a special-purpose application requiring detailed analysis[2].

Fig. 11—T-shaped concrete block which makes possible control of the characteristics of the system, including location of isolators as shown in *Fig.* 10



Further Considerations: Vibration isolators do not depend upon the dissipation of energy in performing their function of force or motion reduction. They operate on the principle of permitting the mounted equipment to move as it tends to move in response to the applied forces and to its own inertia. Isolators have relatively low stiffness to permit this motion of the equipment to take place without transmitting excessive forces to the support. This lack of constraint permits the mounted equipment to experience a relatively large motion if the applied forces are large. In machines such as extractors, looms, and single-cylinder engines or compressors, unbalanced rotating or reciprocating members apply forces that are centrifugal in nature and may become relatively great. Overall motion of the machine may then become so great as to be objectionable for operating purposes. If operating speed of the machine is substantially greater than natural frequency of the isolators, the displacement amplitude (half total travel) x of the machine during vibration is

$$x = \frac{m_m}{m_f} r \qquad (6)$$

where m_f = mass of the entire machine; m_m = mass of the unbalanced rotating or reciprocating parts; and r = radius of the unbalance. The radius of the unbalance is the distance from the axis

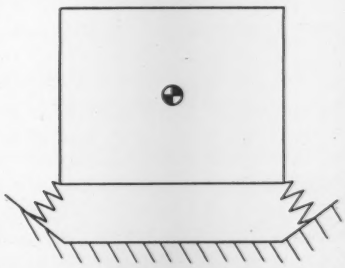


Fig. 12—Another method of decoupling coupled modes—inclining the isolators

of rotation to the center of gravity of the load in the extractor, or one-half the stroke of a reciprocating machine.

Inasmuch as r and m_m are usually functions of the design or operational requirements of the machine, the amplitude of vibration of the complete machine often can be reduced only by increasing m_f. In other words, weight of the machine must be increased so that its own inertia tends to hold it stationary. The vibration-testing machine in *Fig.* 11 is secured to a concrete foundation which in turn is supported by vibration isolators. The mass of the fixed parts of the machine is thus increased and magnitude of vibration of the machine as a whole is reduced.

Care must be taken in the application of isolators to insure that the structure to which the isolator is attached has a greater stiffness than that of the isolator. Failure to take this into consideration may lead to difficulty:

1. Calculations of natural frequency, using the stiffness of the isolator, will be incorrect. The expression for natural frequency given by Equation 2 assumes the mounted equipment to be infinitely rigid. If the equipment is not rigid, its stiffness must be considered with that of the isolator; this series system generally gives a lower overall stiffness than that of the isolator taken alone.
2. Failure to design brackets sufficiently rigid may lead to fatigue failure of the brackets. Isolators are normally constructed to withstand repeated stressing, but this may not be true of brackets. Designers sometimes fail to realize this condition and apply isolators in such a way that the mounting bracket deflects more than the isolator. Care should be taken to insure that mounting brackets are not thus subjected to the possibility of fatigue failure.

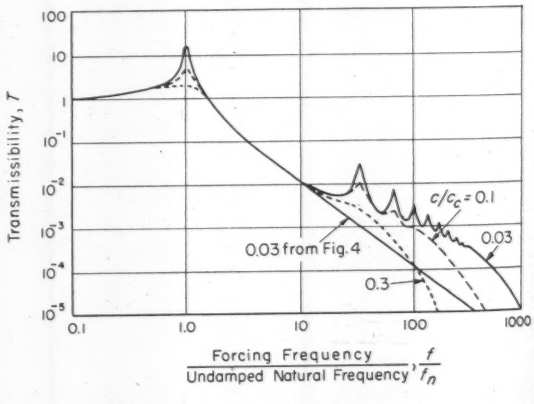
NOISE ISOLATION

The public today is becoming increasingly conscious of noise, and demand for quieter machine operation is widespread. Noise elimination has thus become an important subject. Operation of a machine may be noisy if the machine includes a large surface capable of radiating sound, together with a driving force capable of causing the surface to vibrate. If the driving force cannot be eliminated, it may be possible to quiet the machine by interposing an isolator between the driving force and the surface of the machine capable of radiating the noise. Isolators applied between a machine and the floor are capable only of reducing the vibration of the floor and generally not the vibration of the machine. Consequently, the major quieting effect is noticed in the room below the machine rather than in the same room with the machine because most of the noise in the latter room usually is radiated directly from the machine.

Isolation of noise has much in common with isolation of vibration. Noise isolation involves essentially the reduction of the force that causes a noise-radiating structure to vibrate. If the force is reduced, vibration amplitude of the structure is reduced. It may be said in a qualitative sense that the application of isolators having low force transmissibility tends to effect reduction in the noise level. Determination of the degree of noise reduction introduces complicated quantitative considerations beyond the scope of this article.

The transmissibility curves in *Fig.* 4 assume a single-degree-of-freedom system; weight of the resilient material in the vibration isolator is assumed negligible. This assumption is valid for vibration of relatively low frequency where wave length of the vibration is great relative to the thickness of the resilient material. When the thickness of the resilient material is equal to an integral number of half wave lengths of the vibration, standing wave resonances tend to develop in the resilient material and peaks occur in the transmissibility curve. Typical standing wave resonances are shown in *Fig.* 13 for several degrees of damping, together with a transmissibility curve for a lumped parameter system as illustrated in *Fig.* 4. The transmissibility curves of *Fig.* 13 are the result of a theoretical study,[3] but the principle set forth in this study has been proved by experimental work. It may be noted from *Fig.* 13 that heights of successive standing wave resonances decrease as the forcing frequency increases. At higher frequencies, these resonances disappear entirely. The resilient material then functions as a dissipative

Fig. 13—Typical standing-wave resonances compared with transmissibility curve from *Fig.* 4



medium, and transmissibility continues to decrease at a faster rate than simple theory indicates.

Transmissibility tests of many mounts at relatively high frequencies reveal that the standing-wave resonances illustrated in *Fig.* 13 occur almost inevitably. A reference to the dimensions of commercially available isolators which indicate that standing-wave resonances need not be anticipated at frequencies below about 400 cycles per second. This frequency is well within the range of audible frequencies. Standing wave resonances must therefore be considered a factor in employing isolators for the reduction of noise. The theory suggests certain considerations that may result in alleviation of the effects of such resonances.

Inasmuch as standing-wave resonances are a deviation from the fundamental transmissibility curve, peak amplitudes associated with the resonances may be reduced by lowering the fundamental transmissibility curve in its entirety. This may be accomplished by reducing the fundamental natural frequency of the system. The effectiveness of noise isolation may thus be increased, whether standing-wave resonances are a factor or not, by decreasing the fundamental natural frequency of the isolator system.

Secondly, it is evident from *Fig.* 13 that the amplitudes associated with standing-wave resonances are reduced when the resilient material embodies substantial damping. The curve in *Fig.* 13 for a damping ratio $c/c_c = 0.03$ is typical of natural rubber. The damping ratio for metal springs is much less than for rubber springs. Consequently, the peaks of the standing wave resonances become much greater; test results are on record showing a transmissibility greater than unity at standing-wave resonances in metal springs. Where metal springs must be used to obtain a sufficiently low fundamental natural frequency, the noise-isolating properties of the system may be improved by using a rubber element in series with the metal spring.

If standing-wave resonances become critical and if the forcing frequencies are constant, it may be possible to design isolators to operate between the peaks of standing wave resonances. This is not a straightforward design procedure if the resilient element is a molded rubber part, because it is difficult to calculate the frequencies at which standing-wave resonances occur if the shape of the rubber element is irregular. In general, the lowest frequency at which standing-wave resonances appear can be increased by reducing thickness of the rubber element.

SHOCK ISOLATION

Application of isolators to alleviate the effect of shock is difficult to discuss, partly because the term "shock" has no definite and accepted meaning. It seems to connote suddenness, either in the application of a force, or in the inception of a motion. The nature of the phenomenon may be illustrated by observing the response of an armored vehicle to the impact of a shell. Immediate effect of the impact is to move the armor plate inwardly toward the center of the vehicle. Equipment mounted on the armor plate inboard of the point of impact suddenly finds that its support has acquired a substantial velocity, and that the motion probably will continue until a considerable displacement has resulted. Shock isolators used to mount equipment in such locations must have characteristics adapted to move the equipment gently out of the path of the suddenly moving armor plate. This must be done without damaging the equipment.

Even though the armor plate is moved bodily with a substantial velocity, other parts of the vehicle will probably experience a different effect because the intervening structures may be incapable of transmitting a large force. Such structures deflect elastically instead, and the energy stored in this elastic deformation induces severe vibration of structural members of the vehicle. In parts of the vehicle remote from the impact, the shock is evidenced by this vibration of the structural members with little bodily motion thereof. This phase of shock isolation thereby acquires a great similarity to vibration isolation, except that the shock-excited vibration is transient and may involve substantially greater amplitudes than steady-state vibration.

Because various categories of shock exist, it is not possible to formulate a single procedure that may be used universally in the design and application of shock isolators. It is necessary first to study the mechanics of the system that produces the shock, and then to apply applicable principles in designing and selecting shock isolators.

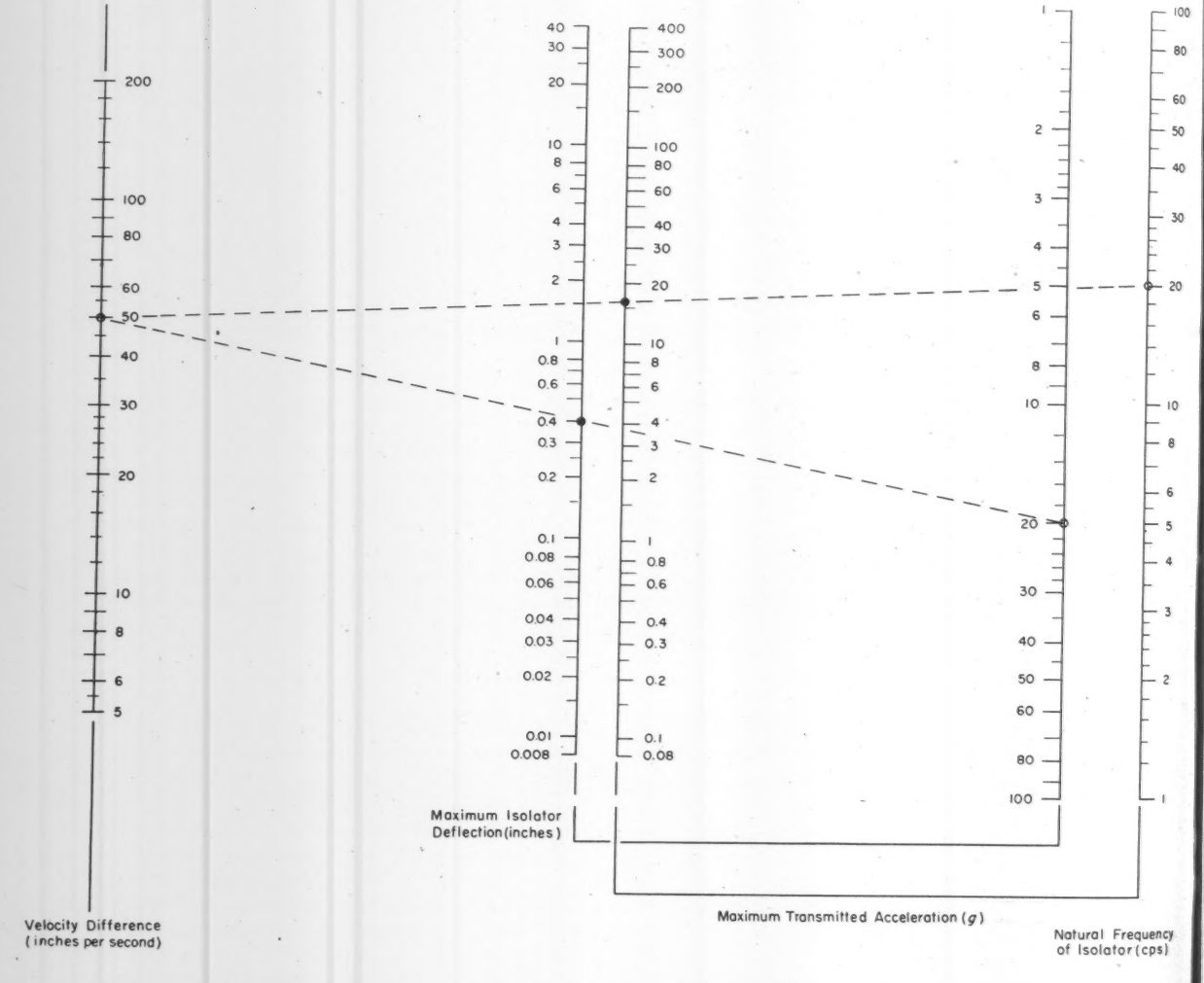
Variable Momentum Systems: One of the most severe requirements for shock isolators occurs when the isolators are required to effect a change in the momentum of a massive body. In a drop-forging machine, for example, the hammer acquires a substantial downward velocity and ultimately strikes the anvil. This imparts a downward velocity to the anvil and associated parts of the forging machine. If the machine is mounted upon shock isolators, these isolators must ultimately reduce its downward velocity to zero while at the same time meeting other requirements in the reduction

of shock. Another example involves the free fall of a packaged article wherein the surface on which the package lands exerts an upward decelerating force that abruptly arrests the downward velocity of the falling package. If the article is packaged with shock isolators between the article and the package, it is a function of the isolators to bring the article to rest without causing damage. As a final example, equipment may be installed in a rail vehicle whose velocity is suddenly changed as a result of impact with another vehicle. Shock isolators used for mounting equipment within the vehicle must bring about a corresponding change in the velocity of the equipment without causing damage.

In all of the previous applications, the shock isolators must have substantial energy storage capacity, because they effect a change in velocity of the mounted equipment. They isolate shock by first storing energy at the relatively high rate associated with the application of shock, and then releasing it at a lower rate which is characteristic of the natural frequency of the isolator. The relation between the energy storage rate and the energy release rate should be chosen so that the mounted equipment receives optimum protection.

For applications in which the isolator is required to effect a change in the velocity of the mounted equipment, *Fig.* 14 may be used to determine the maximum acceleration transmitted to the mounted equipment and the maximum deflection experienced by the isolator. The data in *Fig.* 14 are based on the assumption that the force-deflection curve of the isolator is linear, that structures associated

Fig. 14—Nomograph for determining maximum acceleration and deflection of a system subjected to a shock load



with the isolator are infinitely rigid, and that the indicated deflection does not exceed the maximum permissible deflection of the isolator. The natural frequency of the isolator in *Fig.* 14 is obtained by taking the isolator stiffness in conjunction with the load on the isolator and calculating the natural frequency by substitution in Equation 2. Employing the foregoing examples, the appropriate load is the total weight of the forging machine, the weight of the packaged article, or the weight of the equipment mounted in the rail vehicle, respectively. The maximum acceleration on the right-center scale of *Fig.* 14 is maximum acceleration experienced by this load, considering the load to be an infinitely rigid body, and is known as the rigid-body acceleration.

EXAMPLE 4: Assume that equipment is mounted within the caboose of a freight train on isolators having a natural frequency of 20 cycles per second. During switching operations, the caboose strikes a line of standing freight cars while traveling at a velocity of 50 inches per second. Assuming the motion of the caboose to be arrested instantaneously, the maximum rigid body acceleration experienced by the mounted equipment and the maximum deflection of the isolators are determined from *Fig.* 14. Entering *Fig.* 14 with these values, it is determined that maximum deflection of the isolator is 0.4-inch and maximum acceleration of the mounted equipment is 17*g*. This assumes a linear isolator; the necessary adjustment which must be made if the isolator is nonlinear will be discussed later.

Release of the strain energy stored in the isolator causes the mounted equipment to oscillate at the natural frequency of the system until the energy is dissipated by the damping in the isolator. If the mounted equipment includes structures whose natural frequencies approximate the natural frequency of the equipment on its isolators, a transient resonance tends to develop. As a result, the affected structure of the equipment may vibrate with appreciable amplitude and thereby experience greater acceleration than indicated by *Fig.* 14. Seriousness of this condition depends upon closeness of the match between the natural frequency of the isolator system and the natural frequency of the structural elements of the equipment.

The maximum rigid body acceleration previously obtained from *Fig.* 14 may be corrected to include the effect of the internal resonance by applying the factor obtained from *Fig.* 15. This figure gives an amplification factor which, when multiplied by the previously determined rigid body acceleration, gives an acceleration that represents the maximum acceleration experienced by nonrigid elements of the mounted equipment.

EXAMPLE 5: Assume that the equipment mounted in the caboose, as discussed previously, has a structural element whose natural frequency is 60 cycles per second. The frequency ratio which appears as the abscissa parameter of *Fig.* 15 is, therefore, the quotient of 60 divided by 20, or 3. *Fig.* 15 may now be entered at the value 3 on the horizontal scale. Proceeding vertically to the merged curves representing small damping in the

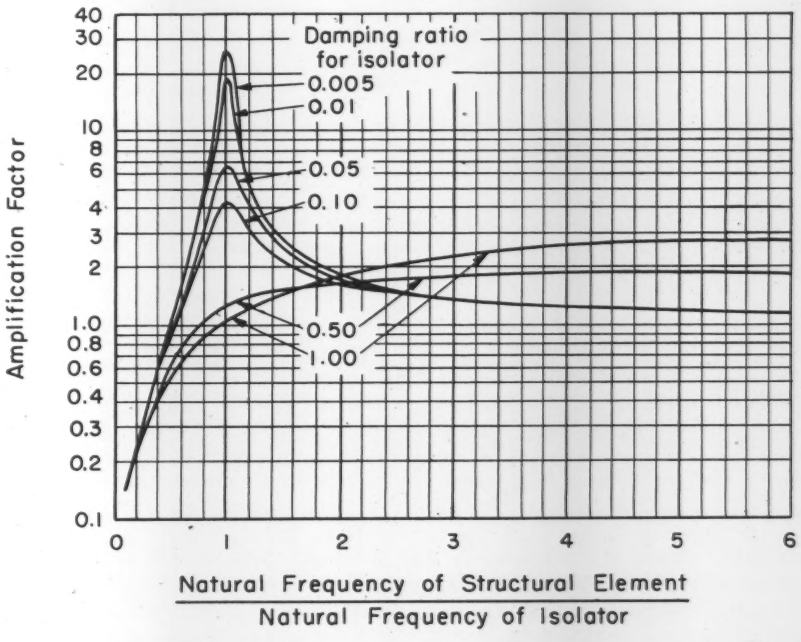


Fig. 15 — Amplification factor for correction of *Fig.* 14 when internal resonance occurs (damping ratio for structural element = 0.01)

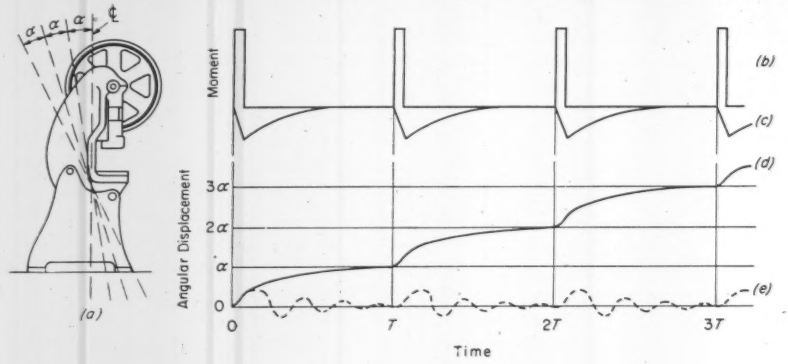


Fig. 16—In a punch press, *a*, total angular momentum remains constant, since pulses produced by punching, *b*, are balanced by moment applied by the motor, *c*. This momentum transformation results in net motion, *d*. Isolators, *e*, restore the press to its original position

isolator, an amplification factor of approximately 1.4 is read from the vertical scale. The previously calculated rigid body acceleration of 17*g* is now multiplied by 1.4 to give an acceleration of approximately 24*g* which is applicable to any structural element having a natural frequency of 60 cycles per second. The structural element must have sufficient strength to withstand the acceleration of 24*g*, even though the isolator and adjacent parts of the chassis will experience a maximum acceleration of only 17*g*.

Constant Momentum Systems: In the previous examples, a massive body acquired a velocity from rest or its velocity was arrested as a result of forces applied through shock isolators. These conditions involve momentum change, and isolators must possess adequate energy storage capacity to effect the momentum change. If there is no change in the overall momentum of the system, but a change in the distribution of momentum within the system, it generally is not essential that the isolators have energy storage capacity but rather only freedom to permit motion as dictated by the momentum transformation. In the punch press shown in *Fig.* 16*a*, for example, the total momentum remains constant. The angular momentum of the flywheel is suddenly reduced during the working stroke, but the angular momentum of the entire press is increased correspondingly. Conversely, the momentum of the flywheel is increased as its velocity is gradually restored by the torque of the motor, and the momentum of the entire press is decreased.

Movement of the press as a result of this momentum transfer is illustrated in *Fig.* 16. The moment applied to the flywheel by the metalworking operation is indicated by the upward pulses, *b* in *Fig.* 16, while the moment applied to the flywheel by the motor is indicated by the downward pulses, *c*. An equal and opposite pattern of moments reacts upon the body of the press, and introduces a tendency for the entire press to rotate in a stepwise manner. Assuming the press to be supported in such a way that its rotation about an axis normal to the paper is freely permitted, its angular position at any instant is that indicated by the solid line in *Fig.* 16*d*. As each working stroke is completed, the body of the press acquires a velocity which is ultimately reduced to zero as the motor functions to increase the velocity of the flywheel. As the body of the press periodically acquires and then loses its velocity, it gains a step of displacement α at each cycle. This is indicated by the successive positions of the initially vertical line in *Fig.* 16*a*, and by the time history shown by the solid line in *Fig.* 16*d*.

If the punch press is mounted on isolators, it cannot continue to rotate indefinitely as suggested by the solid line in *Fig.* 16*d*. After completion of the metalworking stroke, the isolators take command of the press and restore it to its initial position, following the path indicated by the dotted line in *Fig.* 16*e*. The press is then in its normal position when the next metalworking stroke occurs. If the isolators are proper for the application, they interfere but little with the motion of the punch press during the metalworking stroke. By permitting the body of the press to rotate in response to the moments applied during the metalworking operation, a degree of shock isolation is assured. It is not straightforward to calculate the transmissibility of isolators used in this manner. The isolators should have a permissible deflection at least as great as that suggested by the dotted line in *Fig.* 16*e*.

The previous criterion for the design of isolators is difficult to apply without an elaborate analysis of the mounted machine. Such an analysis usually will be found difficult to justify. In most instances, satisfactory isolation will be obtained by noting the duration of the metalworking force as indicated by the upwardly projecting pulse, *b*, in *Fig.* 16 and applying isolators accordingly. If the isolators are selected so that they have a natural period substantially greater than the duration of the metalworking force, the effect is similar to maintaining a large ratio of forcing to natural frequency for conditions of vibration isolation. Isolation then tends to occur in a somewhat analogous manner, but calculation of the results is not so definite.

In punch presses and similar machines, the applied forces are periodic though nonharmonic, and care must be taken to avoid a resonant condition.

As pointed out previously, substantial isolation is assured if the natural period of the isolator system is made great relative to the duration of the metalworking force. Care must be taken to insure, however, that the natural period of the isolator system does not coincide with the period between applications of the metalworking force. It is well-known that resonance occurs when the natural period of an isolator system coincides with the period of a harmonically applied force. A similar type of resonance occurs from a matching of periods when the applied force is nonharmonic. The usual practice is to design the isolator system so that its natural period is greater than the duration of the force, but smaller than the period between applications of force.

Transient Vibration: The third type of shock excitation to be considered is a transient vibration. The forcing frequency in this case is usually a natural frequency of one of the structures through which the shock forces are transmitted. By analogy with the isolation of steady-state vibration, an isolator must have a natural frequency lower than the forcing frequency. The forcing frequency or frequencies are derived from the characteristics of structural members, and are often unknown in the absence of test data. Possibly the only other principal requirement for an isolator is that it be capable of experiencing a deflection at least as great as the displacement amplitude embodied in the vibratory shock motion.

NONLINEAR ISOLATORS

The preceding discussion of vibration and shock isolation presumes that the isolator is linear—the force-deflection curve for the isolator is a straight line. This simplified analysis is entirely adequate for many purposes. In the isolation of steady-state vibration, displacement amplitude is usually small, and nonlinearity of the isolator tends to be unimportant except where deflection resulting from the dead-weight load is relatively great. In the isolation of shock, nonlinearity tends to be more important because large deflections prevail. The degree of isolation may then be substantially affected by the deflection of an isolator to its limit.

In the expressions for natural frequency, Equations 1 and 2, the parameter k is the slope of the force-deflection curve. Where the force-deflection curve is a straight line, as shown in *Fig.* 17, the parameter k is a constant. The force-deflection curve for the isolator may be nonlinear, however, as shown in *Fig.* 18. Assume now that a weight W_1 is applied to this isolator; a deflection d_1 then results. If the system is now vibrated with a relatively small amplitude, the vibration may be considered to consist of moving a point back and forth along the force-deflection curve a small distance on either side of a vertical line extending through d_1. Inasmuch as no other part of the force-deflection curve becomes involved in this vibration, the natural frequency of the system is determined by the characteristics of the isolator in the region of the deflection d_1. The important characteristic is the slope k_1 of a straight line tangent to the force-deflection curve at the deflection d_1; i.e., at the load W_1. These values of k_1 and W_1 may be substituted in Equation 2 to obtain a value of natural frequency which, in turn, may be used in conjunction with *Fig.* 4 to calculate the transmissibility if the forcing frequency is known.

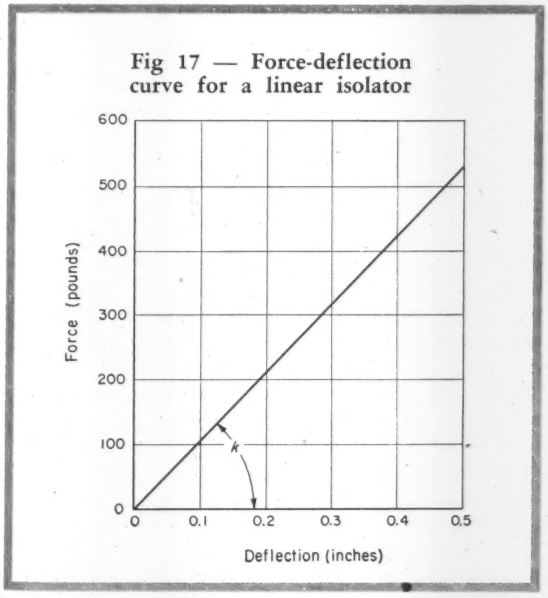


Fig 17 — Force-deflection curve for a linear isolator

If the load applied to a linear isolator is continuously increased, the value of W in Equation 2 continues to increase while the value of k remains constant. The natural frequency of the system thus decreases continuously with an increase in the supported load, as indicated by curve *A* in *Fig.* 19. If the load applied to the nonlinear isolator is continuously increased, a somewhat different result may be obtained. For relatively small loads, the increase in load occurs at a faster rate than the increase in the stiffness of the isolator. The natural frequency, therefore, decreases with an increase in load. For larger loads, however, the stiffness increases at a faster rate than the load, and the natural frequency increases with each addition of load. This is indicated by curve *B* in *Fig.* 19. The natural frequency represented by the

valley of curve B is the minimum that can be attained with an isolator whose force-deflection curve has the characteristics indicated in *Fig.* 18. This distinction between a linear and nonlinear isolator often is not always recognized by designers attempting to decrease the natural frequency by increasing the load.

In determining the natural frequency of a nonlinear isolator, it is important to note whether the load applied to the isolator is massive or nonmassive. If the equipment mounted on the isolator has a weight W_1, the foreging calculation of natural frequency is valid. The weight of the equipment may be only W_0, as indicated in *Fig.* 18, and the incremental load between W_0 and W_1 may result from belt pull or from the sustained acceleration embodied in a rocket takeoff. Inasmuch as a deflection d_1 exists, the appropriate value for stiffness is the slope k_1 of a straight line tangent to the force-deflection curve at the deflection d_1. The only massive load in the isolator system, however, is that associated with the weight W_0. In the use of Equation 2, then, the value of W_0 must be substituted for W and the value of k_1 for k. The natural frequency is then greater than if the load W_1 were used, and the transmissibility is greater. This effect has been investigated in some detail.[4]

In many applications of shock isolators, it is difficult to select or design the isolator because the maximum expected severity of shock cannot be determined. An example set forth previously refers to equipment mounted in a caboose which receives an impact upon striking adjacent cars. The striking velocity is determined by operating conditions on the railroad, and a maximum cannot be definitely specified. If the isolator does not provide for sufficient deflection, hard bottoming may occur with consequent transmission of excessive forces. This consideration makes the use of a linear isolator undesirable. It is often preferable to employ a nonlinear isolator having force-deflection characteristics as illustrated in *Fig.* 18. Such an isolator may be considered linear for small deflections; additional factors must be considered, however, if the applied shock causes deflection well into the nonlinear range.

A procedure for determining the maximum rigid body acceleration transmitted as a result of severe shock makes use of *Fig.* 20. The maximum acceleration and maximum deflection are first calculated for a hypothetical linear isolator whose natural frequency is equal to the natural frequency of the nonlinear isolator at very small deflections. These values of maximum acceleration and maximum deflection, together with the thickness of the nonlinear isolator, can be substituted in *Fig.* 20 to obtain the maximum rigid body acceleration transmitted by the nonlinear isolator. Taking for an example the equipment mounted in a caboose as discussed previously, and assuming the thickness of the resilient material to be $\frac{5}{16}$-inch, the abscissa parameter of *Fig.* 20 is the quotient of the $\frac{5}{16}$-inch thickness divided by the calculated maximum deflection of the linear isolator, 0.4-inch. This gives a value on the abscissa scale of 0.78. Entering *Fig.* 20 at 0.78 the horizontal scale, a value of 3.7 is read from the vertical scale. The previously calculated maximum rigid body accel-

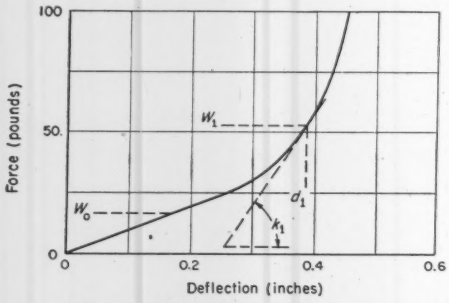


Fig. 18—Above—Force-deflection curve for a nonlinear isolator

Fig. 19—Natural frequency of a linear isolator decreases continuously with increasing load, while nonlinear isolators have a minimum natural frequency

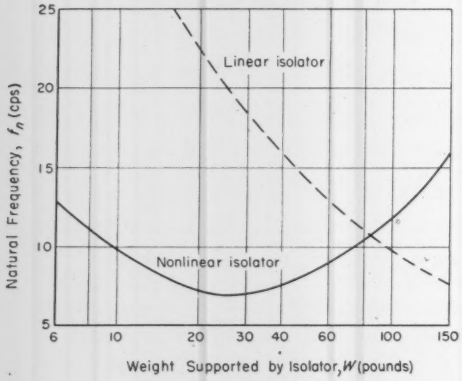


Fig. 20—Chart for determining transmitted maximum acceleration as a result of severe shock for nonlinear isolators

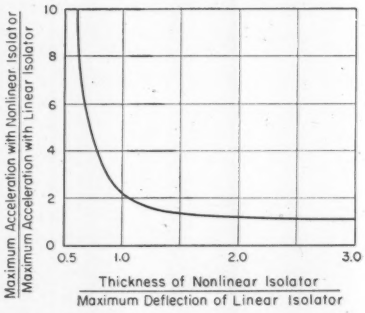
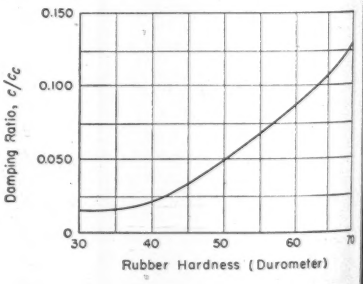


Fig. 21—Variation of damping with hardness in rubber



eration of 17*g* for the linear isolator is now multiplied by 3.7 to give a value of 63*g*. This is the maximum rigid body acceleration of the equipment when supported by nonlinear isolators. The lower acceleration obtained with linear isolators requires more deflection of the isolator, and makes no provision for snubbing in the event of a still greater shock.

ISOLATOR MATERIALS

In selecting a material for the resilient element in an isolator, consideration must be given to many factors. Isolators in use today are made predominately from natural or synthetic rubber although the use of other materials is common. Many advantages derive from the use of rubber:

1. Rubber can be conveniently molded in practically any size or shape, and its stiffness can be readily varied within relatively wide limits. Furthermore, it can be bonded to metallic inserts adapted for convenient attachment to the equipment with which the isolator is used.
2. Rubber embodies a reasonable degree of damping. The damping is not adequate for applications requiring highly damped isolators; it is usually adequate, however, for mounting machines which operate momentarily at resonance during starting and stopping, and it is reasonably satisfactory in damping standing-wave resonances where sound isolation is an important factor. The damping in rubber tends to vary somewhat with the hardness of the material, as indicated in *Fig.* 21.
3. Rubber is well adapted for use in shock isolators, because it has relatively great energy storage capacity per unit weight and because the convenience of molding to any shape makes it possible to attain the nonlinearity required for adequate shock isolation.

Isolators made from rubber having diverse characteristics are commercially available. Each type of isolator has characteristic properties and is particularly suited to certain specialized applications. To make the most intelligent use of available isolators, the designer should understand the basic properties of each type. He should also be familiar with the requirements for isolators in various types of machines, as indicated in the preceding discussion. A number of typical isolators are illustrated in *Fig.* 22 along with corresponding force-deflection curves for a particular isolator of each type. Designations *A* and *B* are used to indicate the direction of the applied force. Numerical values generally range higher and lower than those illustrated, depending upon the size of the isolator and the durometer of the rubber.

Even though rubber has many advantages as the resilient material in an isolator, it also has notable disadvantages. It is not suitable for operation at either extremely high or extremely low temperatures. At temperatures in the range from 175 to 250 F, it tends to age rapidly and develop surface cracks. At higher temperatures, it is completely unsuitable for use extending over an appreciable interval of time. At extremely low temperatures, it tends to become stiff. Minimum usable temperature, except for silicone rubber, varies from −40 to −65 F, depending upon the particular elastomer.

Also, rubber is incapable of continuously withstanding a large strain. An isolator with a relatively great static deflection may give satisfactory performance temporarily, but it tends to drift or creep excessively over a period of time. Opinions on maximum permissible static strain vary widely, but it may be taken as a conservative limitation that rubber should not be continuously strained more than 10 or 15 per cent in compression nor more than 25 or 50 per cent in shear. It is also considered good design practice to limit the static stress at a bonded interface between rubber and steel to approximately 50 psi.

Where rubber is eliminated by one or more of the considerations set forth above, coil springs often are suitable as vibration isolators. Such springs may be loaded in tension, but it is frequently more convenient to load them in compression. The equipment is then set upon the springs with a pilot to locate the springs relative to the equipment, as illustrated in *Fig.* 11. Any required auxiliary devices, such as leveling or snubbing means, can be added without regard to the spring design

Among the advantages of coil springs are the relatively great freedom in obtaining the necessary stiffness characteristics and the freedom from drift or creep. Ratio of vertical to horizontal stiffness, an important characteristic as indicated by *Fig.* 8, can be controlled within wide limits. Equations for the calculation of the stiffness of a coil spring along its central axis are readily available in many engineering handbooks. The stiffness of a spring along its lateral axis has limited engineering applications, and formulas for this stiffness are not so readily available. Lateral stiffness is a function of the coil diameter, the working height of the spring, and its static deflection. The curves in *Fig.* 23 make possible the calculation of the lateral stiffness of the spring if the stiffness along the central axis is known. Stiffness ratio is read from the scale on the vertical axis, based upon known ratios of (1) working height to mean coil diameter, and (2) static deflection to working height.

Coil springs are used in vibration isolators primarily for the isolation of vibration having a low

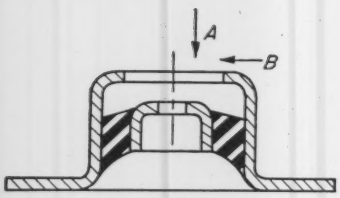
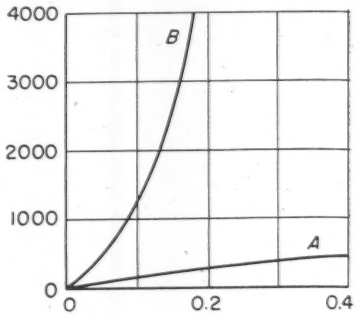
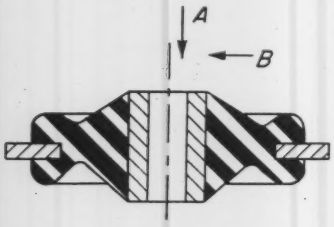
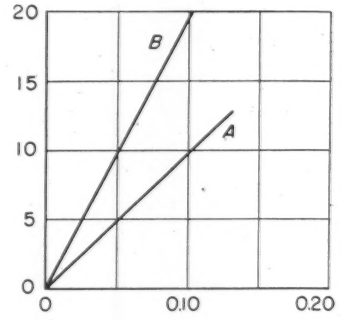
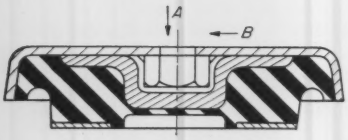
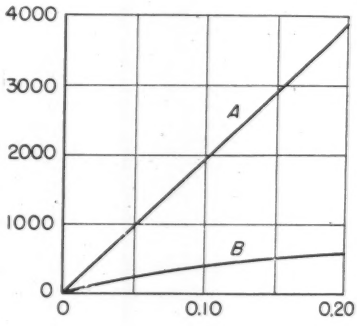
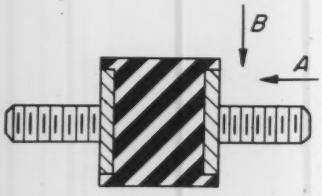
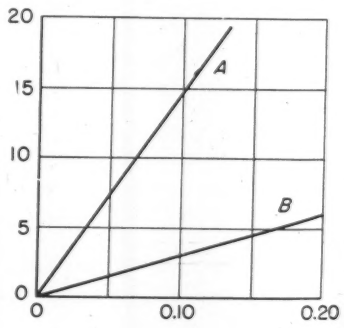
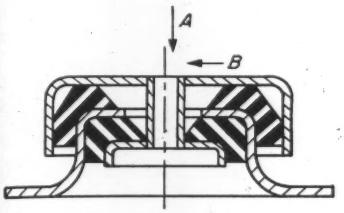
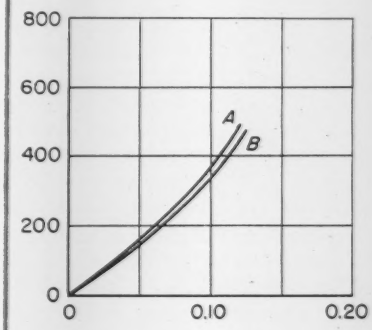
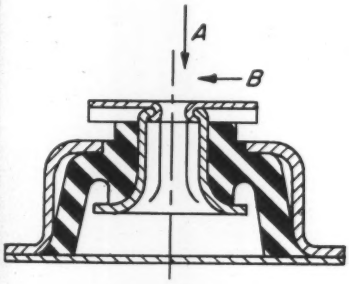
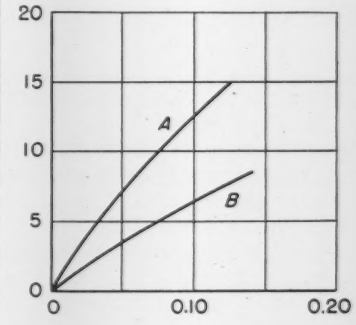
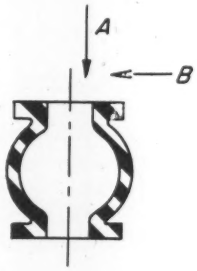
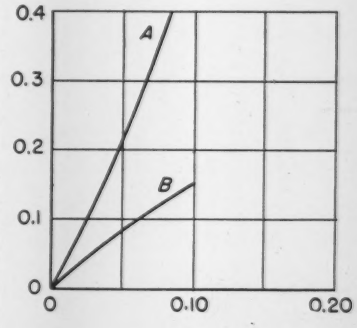
ISOLATOR	DESCRIPTION	Force-Deflection Diagram Horizontal scales = Deflection (inches) Vertical scales = Force (pounds)
	The isolator illustrated extends in a strip normal to the plane of the paper and employs rubber in shear to carry the dead-weight load. The rubber is also strained in shear for deflection perpendicular to the plane of the paper, and in compression for horizontal deflection in the plane of the paper. Stiffness thus tends to be relatively great in the latter direction.	
	In this isolator, the dead-weight load strains the rubber in shear. A force applied to this isolator in any direction causes the rubber to be strained essentially in compression. This isolator is symmetrical with respect to its central vertical axis, and stiffness in any horizontal direction is substantially greater than stiffness in a vertical direction.	
	Resilient material is loaded in compression by the dead-weight load in this isolator, which is also symmetrical with respect to its central vertical axis. Application of a horizontal force in any plane causes the rubber to be strained in shear; horizontal stiffness therefore is substantially less than vertical stiffness.	
	In this isolator, the axis of symmetry extends horizontally, parallel with the threaded studs. The rubber is strained in compression when the load is applied along the axis of symmetry. Stiffness in any direction perpendicular to the axis of symmetry is a function of the shear modulus of the rubber, and tends to be relatively low compared with stiffness along the axis of symmetry.	

FIG. 22

Typical Isolators

ISOLATOR	DESCRIPTION	Force-Deflection Diagram Horizontal scales = Deflection (inches) Vertical scales = Force (pounds)
	The isolator illustrated has a vertical axis of symmetry, and includes rubber that is strained in compression for any direction of load application. The flat parts of the inverted rubber cups are loaded in compression for vertical applications of load, and the peripheral parts of the cups are loaded in compression if a horizontal force is applied to the isolator.	
	This isolator is also symmetrical with respect to its central vertical axis. The rubber element comprises two concentric cylinders connected by a web. The web is strained in shear when the isolator is subjected to a vertical force, and the cylinders are strained in shear when the isolator is subjected to a horizontal force.	
	Symmetrical with respect to the central vertical axis, this isolator is essentially a hollow rubber sphere. When loaded by a vertical force, the sphere tends to be flattened; when loaded by a horizontal force, it tends to roll without changing shape substantially. Consequently, vertical stiffness tends to be appreciably greater than horizontal stiffness.	

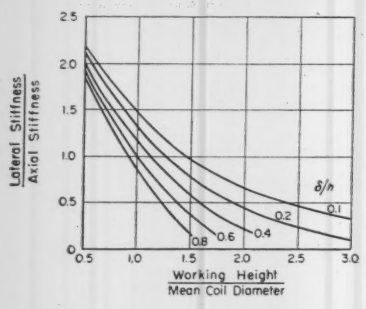


Fig. 23—Determination of lateral stiffness of a coil spring (δ/n = static deflection/ working height)

forcing frequency. Consequently, the coil spring must usually have relatively great static deflection. This introduces the danger of instability with the possibility that the mounted equipment may fall over sideways, unless the precaution has been taken to insure stability of the equipment-and-isolator assembly. Instability is likely to result if the lateral stiffness of the isolator is too small, or if the static deflection is too great. Stable and unstable regions are indicated in *Fig.* 24 in which a straight line indicates the division between these two regions. *Figs.* 23 and 24 are used together by cut-and-try methods in the design of coil springs for vibration isolators.[5]

Other materials frequently are used for vibration and shock isolation. Wool felt is often used for mounting entire machines but is seldom designed as a component part of a machine. A similar situation exists with regard to cork. It is used in both the natural board form and in a form made by compressing cork particles under high pressure and subsequently baking them by means of superheated steam. Another material in the same category is a neoprene-impregnated fabric. Relatively recently, the manufacturers of spun glass have suggested the use of this material for the isolation of vibration. All of these materials appear to have characteristic advantages for particular installations. One of the principal advantages of wool felt is that it may be cemented readily to the floor and to the mounting feet of machinery. Cork is useful under concrete foundations because it can be applied in such a way that it covers the entire areas of the foundation, thereby facilitating the work of pouring a concrete foundation. Cork is more useful than rubber for such an application because it is compressible. Rubber, on the other hand, is incompressible and requires a bulge space if deflection of the rubber is to be realized. Another advantage in the use of cork is that the continuity of the resilient material may make the requirements for a rigid sub-base on the machine less stringent.

The ability of many materials to isolate vibration is difficult to predict. Little difficulty is encountered in the design of isolators using steel springs because the natural frequency and transmissibility calculated on the basis of static properties of the steel spring can usually be checked experimentally within close limits. In making a similar calculation on a rubber isolator, a correction of appreciable magnitude must be introduced. The correction takes into consideration the fact that the dynamic modulus of rubber tends to be greater than the static modulus. Relation between dynamic and static moduli for various hardnesses of rubber is indicated in *Fig.* 25. Transmissibility of a rubber isolator is best determined by conducting a vibration test under selected convenient conditions to determine the natural frequency; the dynamic stiffness is then calculated from this result and used where applicable in the calculation of transmissibility.

Other organic materials appear to behave similarly to rubber, except that the results become still more difficult to predict. The dynamic properties of these materials are not well documented in the technical literature. From the information available, it appears that the natural frequency is greater than anticipated on the basis of static properties and the transmissibility at high forcing frequencies is greater than anticipated on the basis of natural frequency. The transmissibility should be checked under actual operating conditions to determine the effectiveness of the isolators.

REFERENCES

1. Charles E. Crede—*Vibration and Shock Isolation*, John Wiley and Sons Inc., New York, 1951, Page 49.
2. Ibid., Pages 73-87.
3. Mark Harrison, Allan O. Sykes and M. Martin—"Wave Effects in Isolation Mounts," *Journal of the Acoustical Society of America*, Vol. 24, No. 1, January, 1952.
4. Charles E. Crede—"Natural Frequency of a Nonlinear System Subjected to a Non-Massive Load." *Trans. ASME*, Vol. 76, No. 1, January, 1954.
5. Reference 1, Pages 248-249.

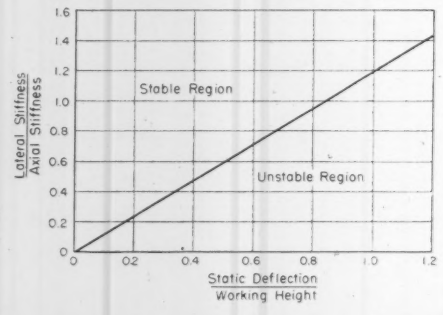
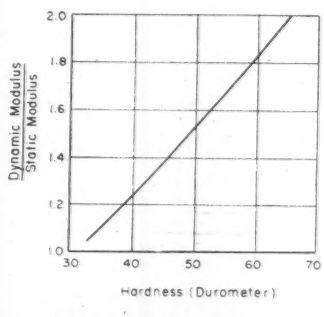


Fig. 24—Left—stability of coil springs for vibration isolators

Fig. 25—Right—Relation between dynamic and static moduli for various rubber hardnesses



Maximum Shear Stress

. . . a clarification of some misconceptions in the calculation of stress at a point for two-dimensional loading

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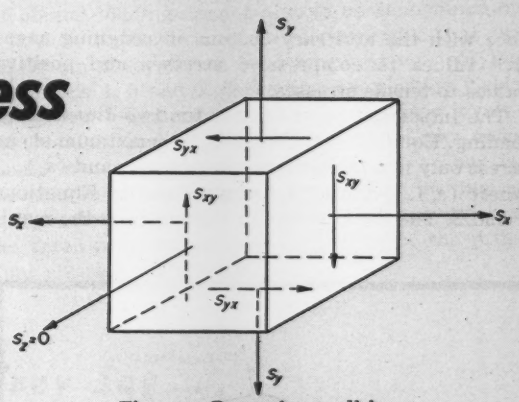


Fig. 1—General condition of two-dimensional stress

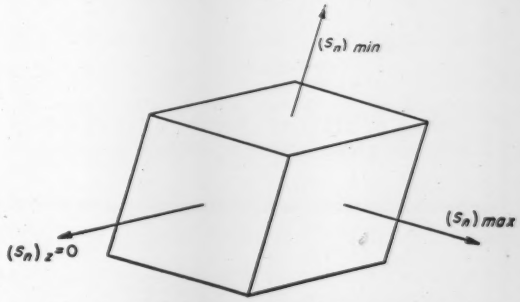


Fig. 2—Maximum and minimum normal stresses for two-dimensional loading

STRESS analysis can be organized on a logical enough basis, but sometimes pitfalls occur in even the most rational procedures. One particular hazard is frequently present in the calculation of the maximum shear stress at a point for the case of biaxial combined stress. It is the blind usage of the commonly recommended design equation:

$$(s_s)_{max} = \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_{xy}^2} \quad \ldots\ldots\ldots\ldots (1)$$

where s_x and s_y are normal stresses in the direction of the X-axis and Y-axis, s_{xy} is the shear stress in the plane of the axes, and $(s_s)_{max}$ is the maximum shear stress.

Equation 1 may not be used indiscriminately as a design equation since it determines the maximum shear stress only in the plane of the evaluated stresses, s_x and s_y. Quite often a greater shear stress exists at the given point, but in another plane. The designer is interested in the maximum shear stress at the point being investigated regardless of the plane in which it falls. Equation 1 is not always valid for evaluating the maximum shear stress at a point because a triaxial stress condition exists even though one of the principal stresses is zero.

The state of stress at a point with two-dimensional loading may be shown diagrammatically by representing the point under consideration as a solid cube of infinitesimal dimensions, *Fig.* 1. For this two-dimensional stress condition where the normal stress s_z is zero, standard derivations yield the following expressions for the maximum and minimum algebraic values of the normal stresses at the point:

$$(s_n)_{max} = \frac{s_x + s_y}{2} + \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_{xy}^2} \quad \ldots\ldots (2)$$

$$(s_n)_{min} = \frac{s_x + s_y}{2} - \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_{xy}^2} \quad \ldots\ldots (3)$$

The maximum and minimum normal stresses as determined by Equations 2 and 3 are either tensile or compressive and act on principal planes of zero shear. In *Fig.* 2 the faces of the cube represent the principal planes upon which the maximum and minimum normal stresses act.

For two-dimensional stress, as shown in *Figs.* 1 and 2, standard derivations yield the following expression for the maximum shear stress in a *plane containing the maximum and minimum normal stresses,* as shown in *Fig.* 3:

$$(s_s)_{max} = \frac{(s_n)_{max} - (s_n)_{min}}{2} \quad \ldots\ldots\ldots\ldots (4)$$

In Equations 2, 3, and 4 it should be noted that s_x, s_y, $(s_n)_{max}$, and $(s_n)_{min}$ are algebraic values and that they may be either plus or minus in accord-

MAXIMUM SHEAR STRESS

ance with the arbitrary custom of assigning negative values to compressive stresses and positive values to tensile stresses.

The important point is that for two-dimensional loading, Equation 4 determines the maximum shear stress only in a plane containing $(s_n)_{max}$ and $(s_n)_{min}$ where $(s_n)_{max}$ and $(s_n)_{min}$ are defined by Equations 2 and 3. The shear stress in this plane is the maximum shear stress at the point only if $(s_n)_{max}$ and $(s_n)_{min}$ have different algebraic signs. In this event the maximum shear stress at the point may be determined by either Equations 1 or 4. However, if $(s_n)_{max}$ and $(s_n)_{min}$ are of the same sign, the maximum shear stress at the given point lies in a different plane and cannot be determined by either Equations 1 or 4. For this latter condition, where the maximum and minimum normal stresses are of the same sign, the designer should note that biaxial loading is really the special case of triaxial loading, with the third principal stress $(s_n)_z$ being zero. For this case, the absolute minimum normal stress is zero and the absolute maximum normal stress is either $(s_n)_{max}$ or $(s_n)_{min}$ depending upon which is numerically greater, and the maximum shear stress actually lies in a plane at 45 degrees to the plane containing $(s_n)_{max}$ and $(s_n)_{min}$.

Fig. 4 illustrates the situation where $(s_n)_{max}$ and $(s_n)_{min}$ as calculated by Equations 2 and 3

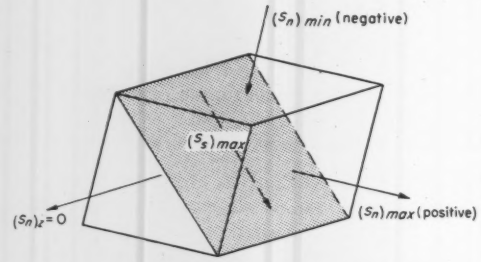


Fig. 3 — Maximum and minimum normal stresses of different sign for biaxial loading and the plane of the maximum shear stress

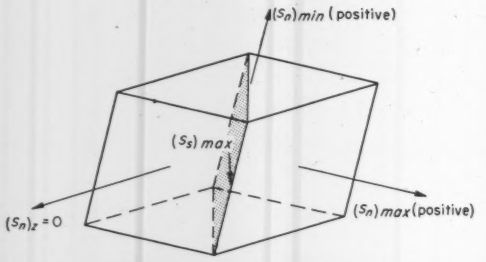


Fig. 4—Maximum and minimum normal stresses of the same sign (both positive) and the plane of the maximum shear stress

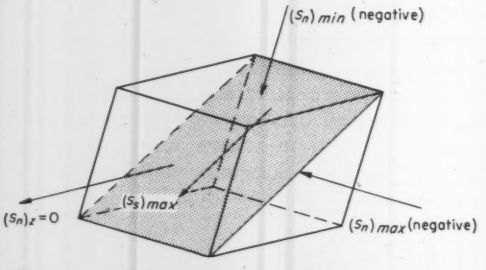
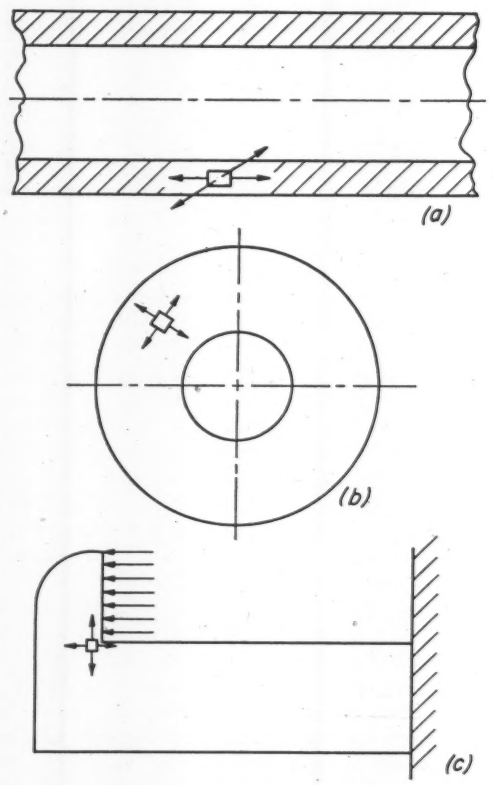


Fig. 5 — Maximum and minimum normal stresses of the same sign (both negative), and the plane of the maximum shear stress

Fig. 6—Examples of biaxial loading where the maximum and minimum stresses are of the same sign: (a) thin-walled air cylinder showing longitudinal and hoop stresses (both positive); (b) turbine rotor showing radial and circumferential stresses (both positive); and (c) latch with uniform load showing s_x and s_y stresses (both positive)



are both positive, showing that

$$(s_s)_{max} = \frac{(s_n)_{max} - 0}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

when $(s_n)_{max}$ is numerically greater than and of the same sign as $(s_n)_{min}$.

Fig. 5 illustrates the situation where $(s_n)_{max}$ and $(s_n)_{min}$ as calculated by Equations 2 and 3 are both negative, showing that

$$(s_s)_{max} = \frac{(s_n)_{min} - 0}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

when $(s_n)_{min}$ is numerically greater and of the same sign as $(s_n)_{max}$.

The following example shows the serious error that can be made by using Equation 1 for calculating the maximum shear at a point. Given data are

$$s_x = +\,12{,}000 \text{ psi}$$
$$s_y = +\,\ 8{,}000 \text{ psi}$$
$$s_{xy} = 2{,}000 \text{ psi}$$

From Equation 1,

$$(s_s)_{max} = \sqrt{\left(\frac{12{,}000 - 8000}{2}\right)^2 + (2000)^2} = 2380 \text{ psi}$$

But, working with the maximum difference of two principal stresses, with the third principal stress being zero, gives from Equation 2

$$(s_n)_{max} = \frac{12{,}000 + 8000}{2} + \sqrt{\left(\frac{12{,}000 - 8000}{2}\right)^2 + (2000)^2}$$
$$= 12{,}830 \text{ psi}$$

From Equation 3

$$(s_n)_{min} = \frac{12{,}000 + 8000}{2} - \sqrt{\left(\frac{12{,}000 - 8000}{2}\right)^2 + (2000)^2}$$
$$= 7170 \text{ psi}$$

From Equation 5

$$(s_s)_{max} = \frac{(s_n)_{max} - 0}{2} = \frac{12{,}830 - 0}{2}$$
$$= 6415 \text{ psi}$$

For this example, the actual maximum shear stress is 6415 psi and not 2830 psi, as indicated by Equation 1. It is to be noted that the actual maximum shear stress for this problem is over 200 per cent greater than that determined by Equation 1. The situations where the maximum shear stress at a point must be calculated by using Equations 5 or 6 are many. Typical examples are encountered in pressure vessels, in gas turbine rotors, various latch arrangements, etc., as shown in *Fig.* 6.

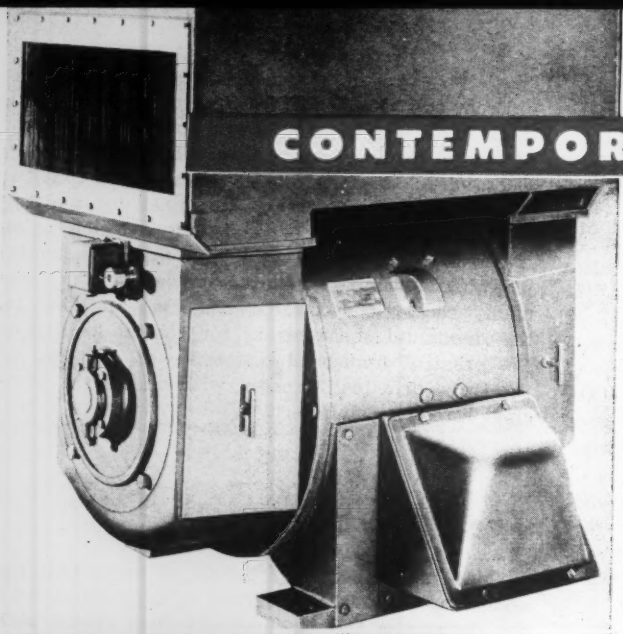
From this discussion, it is seen that the maximum shear stress at a given point for the case of biaxial loading cannot always be determined by Equation 1. It is therefore recommended that the maximum shear stress be determined by applying Equations 4, 5 and 6, depending upon which yields the greatest numerical value, for all cases involving biaxial combined stress, instead of the commonly recommended shear Equation 1. That is, the maximum shear stress for biaxial loading is the greatest numerical difference of any two of the three principal stresses, with one of the principal stresses being zero.

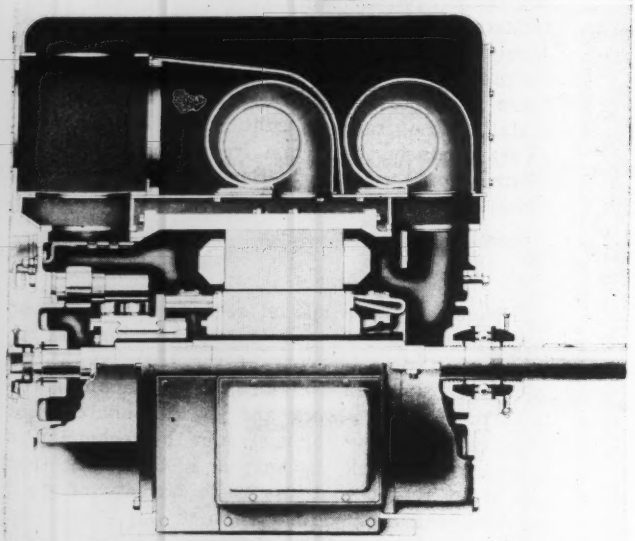
They Say . . .

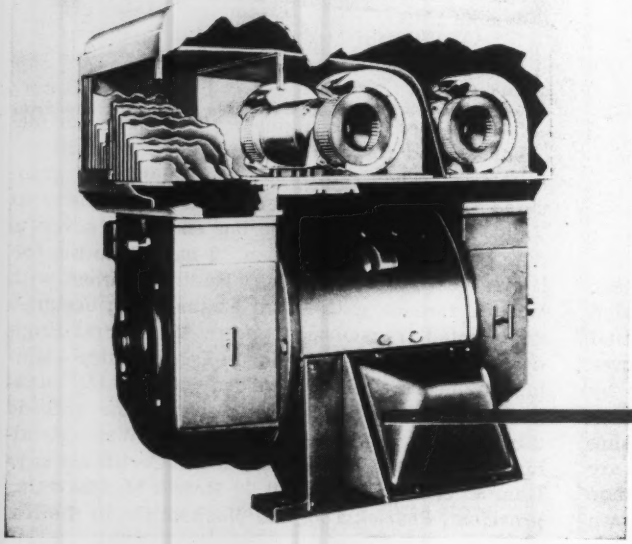
"Modern industry is a fabric of many patterns and many threads. One thread running through all the designs is the engineer. He has grown with industry to be among its leaders. He is established throughout it in the development and design of its products. He builds in its construction. He directs its processes. He establishes its tools. He installs and operates its utilities. And he sells many of its products. Take him from industry, and industry would collapse."—EVERETT S. LEE, *editor, General Electric Review.*

"Engineers have special responsibilities in our society because they have special training and because they represent one of the basic moralities of our society. In a civilization of machines, the machines have to work and the dependability of the craftsman, the engineer, and the technician is primary. So well discharged is this duty that we often forget that the basic honesty of good workmanship is the foundation of our social and material system."—DR. LYMAN BRYSON, *guest professor, Mechanical Engineering Department. Columbia University.*

"An engineer is an engineer. The course for mechanicals and for electricals is the same until the last year. Then the difference is minor. I graduated from M. I. T. (after a four year course at Yale) in electrical engineering and have never to date practiced my profession. I have done the following feats of engineering: Built a railroad with bridges, tunnels, cuts—Civil Engineering; designed and erected transmission towers—Structural Engineering; located a gold mine in Death Valley—Mining Engineering; electric welded "unweldable" manganese-vanadium so as to deliver some torpedo tubes to the U. S. Navy during the War—Metallurgical Engineering. But my State Certificate says I am an electrical engineer."—RALPH M. SHAW JR., *president, Pedrick Tool and Machine Co.* in the November, 1953 *Houghton Line.*





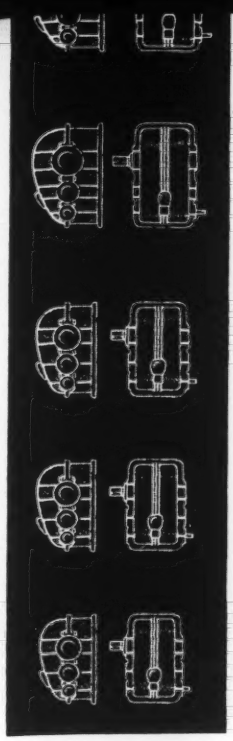


Motor Has Independent Cooling System

VENTILATION of a series of new unit-cooled dc motors developed by General Electric Co. is completely independent of the speed of the motor. Ventilating blowers are driven by standard totally enclosed induction motors. Intended for application where severe atmospheric conditions make open or partially enclosed motors difficult to maintain, the new motors are available in both constant and adjustable-speed types.

Cooling air from the atmosphere is forced through the external passages of the motor by one blower. Another blower assembly forces internal air through closed internal passages of the motor. Length and width of the cooling unit are no greater than like dimensions of the motor proper. Motor frames are the same size as standard open motors. Blower motors may be for polyphase ac operation or dc.

Commutator access door permits easy servicing of commutator brushes and brush rigging. No tools are needed to remove the heavy steel, gasketed doors. A thermostatic relay at the commutator end of the motor provides protection in the event of blower motor power supply failure. Relay contacts may be used to stop the main motor or sound an alarm.



Fundamental concepts and design criteria for a systematic approach to machine series planning have been discussed in Part 1 of this series of articles. This article will deal with the analytical techniques of the approach, with particular emphasis on second-order progressions — their theory and application as a planning tool. Succeeding articles will treat the methods of attack for practical problems encountered with specific machines.

Planning Machine Series—2

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IN CONVENTIONAL geometrical progressions, the constant value of the ratio r between subsequent terms is the significant identifying characteristic of the numerical sequence. A typical example is the seven term progression: 100, 133, 178, 237, 316, 422, 562. For this series of terms the ratio between adjoining terms has a constant value of 1.334.

However, in second order geometrical progressions, particularly those of a form suitable for application to the study of machine lines, the ratio diminishes from an initial maximum to a final minimum value. For example:

Term	Value	Ratio	Term	Value	Ratio
1	100	...	5	417	1.29
2	159	1.59	6	501	1.20
3	234	1.48	7	562	1.12
4	324	1.38			

For each term, the ratio represents the quotient of the corresponding and preceding term values.

The law governing the numerical variation of the ratios in a decreasing series could, of course, take any form desired. For machine series, the calculations and planning become easier and more logical if the ratios of the term values follow, in turn, a geometrical progression having a ratio less than 1. Progressions determined from these criteria are defined as "second order." In the preceding example of a second order progression, the ratio of the progression of term ratios is 0.933.

Fundamental Relationships: Second order geometrical progressions are thus defined as any geometrical progression having a ratio which, instead of remaining constant, varies according to an ordinary geometrical progression. Let (1) $a, b, c \ldots k$ and l be the values, always positive, of the terms of a progression; (2) n be the number of terms in the progression, including the first and the last; (3) r be the first ratio, i.e., the ratio between the

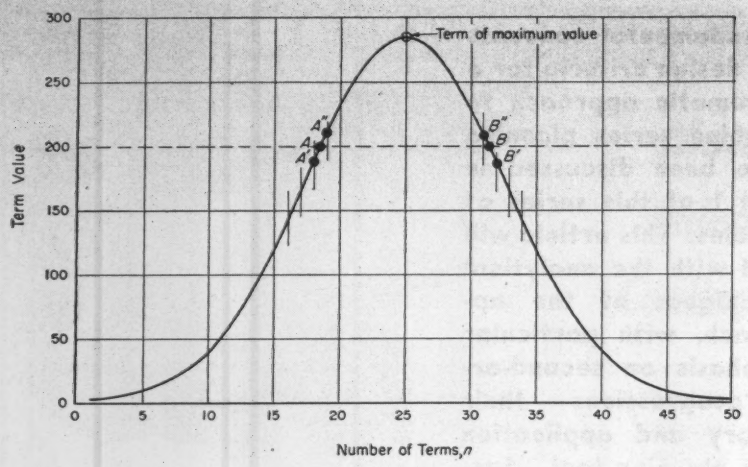


Fig. 8—Plot of term values versus number of terms for an unlimited second-order progression

second and the first term; (4) r_n be the last ratio, i.e., the ratio between the last term of order n and the penultimate term k of order n-1; and (5) ρ be the second-order ratio, i.e., the constant ratio of the progression of ratios. Then, by definition:

$$\frac{b}{a} = r \quad \ldots\ldots (7)$$

$$\frac{c}{b} = r\rho \quad \ldots\ldots (8)$$

$$\frac{d}{c} = r\rho^2 \quad \ldots\ldots (9)$$

$$\ldots \frac{l}{k} = r\rho^{n-2} = r_n \quad \ldots\ldots (10)$$

Combining all right-hand terms and all left-hand terms by multiplication and setting the products equal,

$$l = ar^{n-1}\,\rho^{1+2+3+\ldots+(n-2)} \quad \ldots\ldots (11)$$

The numerical value of the exponent of ρ in Equation 11 can be readily determined. It is equal to 0 for the first ratio and to 1 for the second. Beyond the third ratio the exponent is the sum of the first n-2 natural numbers. This sum, which shall be denoted by Σ, is equal to

$$\Sigma = \frac{(n-2) + (n-2)^2}{2} \quad \ldots\ldots (12)$$

Thus,

$$l = ar^{n-1}\,\rho^{\Sigma} \quad \ldots\ldots (13)$$

Equation 13 gives the value of any term of order n, and is particularly useful for finding the value of the last term l, where n is the number of terms in the progression. The value of the last ratio, r_n, may be found from Equation 10.

In this discussion, attention will be given only to those progressions having positive terms continuously increasing from a to l and ratios, of values always greater than 1, continuously decreasing from r to r_n. Corresponding conditions of analysis are summarized by the following limitations:

$$a > 0, \quad r > 1, \quad 0 < \rho < 1, \quad r\rho^{n-2} > 1$$

Table 3—Basic Preferred Numbers*

5-series	10-series	20-series	40-series	Mantissa
10	10	10	10	000
			10.6	025
		11.2	11.2	050
			11.8	075
	12.5	12.5	12.5	100
			13.2	125
		14	14	150
			15	175
16	16	16	16	200
			17	225
		18	18	250
			19	275
	20	20	20	300
			21.2	325
		22.4	22.4	350
			23.6	375
25	25	25	25	400
			26.5	425
		28	28	450
			30	475
	31.5	31.5	31.5	500
			33.5	525
		35.5	35.5	550
			37.5	575
40	40	40	40	600
			42.5	625
		45	45	650
			47.5	675
	50	50	50	700
			53	725
		56	56	750
			60	775
63	63	63	63	800
			67	825
		71	71	850
			75	875
	80	80	80	900
			85	925
		90	90	950
			95	975

* Abstracted from *American Standard Preferred Numbers*—ASA Z17.1-1936 (Reaffirmed 1946). Preferred numbers above 100 and below 10 are formed by multiplying or dividing the numbers between 10 and 100 by 10, by 100 etc.

Term Values: If a progression of the type just described is extended without any limitation on the number of terms, disregarding the condition $r\rho^{n-2} > 1$, the values of the terms will reach a maximum and then decrease. This characteristic can be readily proved by analysis of the general ratio expression, $r\rho^{n-2}$. Since $\rho < 1$, it is evident that a value of n exists for which $r\rho^{n-2} < 1$.

A curve of the term values of a second-order progression with $\rho < 1$, plotted against the number of terms, is shown in *Fig.* 8. From the foregoing discussion, it is evident that only the initial branch of the curve, between the first term and the term of maximum value, need be taken into account.

Last Ratio: For an n-term progression, the last ratio, r_n, may be determined from Equation 10, using the right-hand equality. As in the case of monomial expressions including a power of any exponent, calculations are simplified if this expression is transformed to its logarithmic form,

$$\log r_n = \log r + (n - 2) \log \rho \quad \ldots\ldots (14)$$

This equation, together with the following three expressions derived from it, give each one of the four variables in terms of the other three:

$$\log r = \log r_n - (n - 2) \log \rho \quad \ldots\ldots (15)$$

$$\log \rho = \frac{\log r_n - \log r}{(n - 2)} \quad \ldots\ldots (16)$$

$$n = \frac{\log r_n - \log r}{\log \rho} + 2 \quad \ldots\ldots (17)$$

Number of Terms: Changing Equation 13 to its

Table 4—Basic Data for Planned Progressions

Series	l/a	log (l/a)	n	n-1	n-2	log (rr_n)	log r	log r_n	log ρ	r	r_n	ρ
6–4–A	5.62	0.75	4	3	2	0.500	0.400	0.100	−0.15000	2.51	1.26	0.708
6–4–B	5.62	0.75	4	3	2	0.500	0.350	0.150	−0.10000	2.24	1.41	0.794
6–4–C	5.62	0.75	4	3	2	0.500	0.300	0.200	−0.05000	2.00	1.58	0.891
6–7–A	5.62	0.75	7	6	5	0.250	0.200	0.050	−0.03000	1.58	1.12	0.933
6–7–B	5.62	0.75	7	6	5	0.250	0.150	0.100	−0.01000	1.41	1.26	0.977
6–13–A	5.62	0.75	13	12	11	0.125	0.100	0.025	−0.00682	1.26	1.06	0.985
6–13–B	5.62	0.75	13	12	11	0.125	0.075	0.050	−0.00228	1.19	1.12	0.995
10–5–A	10.0	1.00	5	4	3	0.500	0.400	0.100	−0.10000	2.51	1.26	0.794
10–5–B	10.0	1.00	5	4	3	0.500	0.350	0.150	−0.06677	2.24	1.41	0.858
10–5–C	10.0	1.00	5	4	3	0.500	0.300	0.200	−0.03333	2.00	1.59	0.926
10–9–A	10.0	1.00	9	8	7	0.250	0.200	0.050	−0.02143	1.58	1.12	0.952
10–9–B	10.0	1.00	9	8	7	0.250	0.150	0.100	−0.00714	1.41	1.26	0.984
10–17–A	10.0	1.00	17	16	15	0.125	0.100	0.025	−0.00500	1.26	1.06	0.989
10–17–B	10.0	1.00	17	16	15	0.125	0.075	0.050	−0.00167	1.19	1.12	0.992
18–6–A	17.8	1.25	6	5	4	0.500	0.450	0.050	−0.10000	2.82	1.12	0.794
18–6–B	17.8	1.25	6	5	4	0.500	0.400	0.100	−0.07500	2.51	1.26	0.841
18–6–C	17.8	1.25	6	5	4	0.500	0.300	0.200	−0.02500	2.00	1.58	0.944
18–11–A	17.8	1.25	11	10	9	0.250	0.225	0.025	−0.02222	1.68	1.06	0.950
18–11–B	17.8	1.25	11	10	9	0.250	0.200	0.050	−0.01667	1.58	1.12	0.962
18–11–C	17.8	1.25	11	10	9	0.250	0.150	0.100	−0.00555	1.41	1.26	0.987
18–21–A	17.8	1.25	21	20	19	0.125	0.100	0.025	−0.00395	1.26	1.06	0.991
18–21–B	17.8	1.25	21	20	19	0.125	0.075	0.050	−0.00132	1.19	1.12	0.997
32–7–A	31.6	1.50	7	6	5	0.500	0.450	0.050	−0.08000	2.82	1.12	0.832
32–7–B	31.6	1.50	7	6	5	0.500	0.400	0.100	−0.06000	2.51	1.26	0.871
32–7–C	31.6	1.50	7	6	5	0.500	0.300	0.200	−0.02000	2.00	1.58	0.955
32–13–A	31.6	1.50	13	12	11	0.250	0.225	0.025	−0.01818	1.68	1.06	0.959
32–13–B	31.6	1.50	13	12	11	0.250	0.200	0.050	−0.01364	1.58	1.12	0.969
32–13–C	31.6	1.50	13	12	11	0.250	0.150	0.100	−0.00454	1.41	1.26	0.990
32–25–A	31.6	1.50	25	24	23	0.125	0.100	0.025	−0.00326	1.26	1.06	0.993
32–25–B	31.6	1.50	25	24	23	0.125	0.075	0.050	−0.00109	1.19	1.12	0.998
56–8–A	56.2	1.75	8	7	6	0.500	0.475	0.025	−0.07500	2.99	1.06	0.841
56–8–B	56.2	1.75	8	7	6	0.500	0.450	0.050	−0.06667	2.82	1.12	0.858
56–8–C	56.2	1.75	8	7	6	0.500	0.400	0.100	−0.05000	2.51	1.26	0.891
56–8–D	56.2	1.75	8	7	6	0.500	0.300	0.200	−0.01667	2.00	1.58	0.962
56–15–A	56.2	1.75	15	14	13	0.250	0.225	0.025	−0.01538	1.68	1.06	0.965
56–15–B	56.2	1.75	15	14	13	0.250	0.200	0.050	−0.01154	1.58	1.12	0.974
56–15–C	56.2	1.75	15	14	13	0.250	0.150	0.100	−0.00385	1.41	1.26	0.9912
56–29–A	56.2	1.75	29	28	27	0.125	0.100	0.025	−0.00278	1.26	1.06	0.9936
56–29–B	56.2	1.75	29	28	27	0.125	0.075	0.050	−0.00093	1.19	1.12	0.9997
100–9–A	100.0	2.00	9	8	7	0.500	0.475	0.025	−0.06429	2.99	1.06	0.862
100–9–B	100.0	2.00	9	8	7	0.500	0.450	0.050	−0.05714	2.82	1.12	0.877
100–9–C	100.0	2.00	9	8	7	0.500	0.400	0.100	−0.04286	2.51	1.26	0.906
100–9–D	100.0	2.00	9	8	7	0.500	0.300	0.200	−0.01429	2.00	1.58	0.968
100–17–A	100.0	2.00	17	16	15	0.250	0.225	0.025	−0.01333	1.68	1.06	0.970
100–17–B	100.0	2.00	17	16	15	0.250	0.200	0.050	−0.01000	1.58	1.12	0.977
100–17–C	100.0	2.00	17	16	15	0.250	0.150	0.100	−0.00333	1.41	1.26	0.9924
100–33–A	100.0	2.00	33	32	31	0.125	0.100	0.025	−0.00242	1.26	1.06	0.9945
100–33–B	100.0	2.00	33	32	31	0.125	0.075	0.050	−0.00081	1.19	1.12	0.9981

logarithmic form gives the general formula linking the elements of the progression, including the values of the first and last terms:

$$\log l = \log a + (n-1)\log r + \frac{(n-2)+(n-2)^2}{2}\log \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

Transforming Equation 18 into its quadratic form and solving for the number of terms, by means of the quadratic formula gives

Table 5
Planned Progressions

Terms — Ratios
Nominal Range Ratio = 6

6-4-A		6-7-A		6-13-A		6-13-B	
1.000	....	1.000	....	1.000	....	1.000	....
2.512	2.512	1.585	1.585	1.259	1.259	1.189	1.189
4.467	1.778	2.344	1.479	1.560	1.239	1.405	1.182
5.623	1.259	3.236	1.380	1.903	1.220	1.653	1.176
		4.169	1.288	2.286	1.201	1.933	1.170
6-4-B		5.012	1.202	2.703	1.182	2.250	1.164
1.000	....	5.623	1.122	3.146	1.164	2.605	1.158
2.239	2.239			3.604	1.146	3.004	1.152
3.981	1.778	6-7-B		4.065	1.128	3.437	1.146
5.623	1.413	1.000	....	4.513	1.110	3.917	1.140
		1.412	1.412	4.933	1.093	4.441	1.134
6-4-C		1.950	1.380	5.308	1.076	5.007	1.128
1000	....	2.630	1.349	5.622	1.059	5.617	1.122
1.995	1.995	3.467	1.318				
3.548	1.778	4.467	1.288				
5.623	1.585	5.623	1.259				

Terms — Ratios
Nominal Range Ratio = 10

10-5-A		10-9-A		10-17-A		10-17-B	
1.000	....	1.000	....	1.000	....	1.000	....
2.512	2.512	1.585	1.585	1.259	1.259	1.189	1.189
5.012	1.995	2.391	1.509	1.567	1.244	1.407	1.179
7.943	1.585	3.433	1.436	1.928	1.230	1.660	1.170
10.000	1.259	4.693	1.367	2.344	1.216	1.950	1.161
		6.105	1.301	2.818	1.202	2.282	1.153
10-5-B		7.560	1.238	3.350	1.188	2.661	1.144
1.000	....	8.912	1.179	3.936	1.175	3.090	1.135
2.239	2.239	10.000	1.122	4.571	1.161	3.578	1.126
4.299	1.920			5.248	1.148	4.120	1.118
7.079	1.647	10-9-B		5.957	1.135	4.730	1.109
10.000	1.413	1.000	....	6.684	1.122	5.409	1.101
		1.413	1.413	7.413	1.109	6.163	1.092
10-5-C		1.963	1.390	8.128	1.096	6.994	1.084
1000	....	2.683	1.367	8.811	1.084	7.907	1.076
1.995	1.995	3.607	1.345	9.441	1.072	8.907	1.068
3.687	1.848	4.771	1.323	10.000	1.059	10.000	1.060
6.311	1.712	6.207	1.301				
10.000	1.585	7.944	1.280				
		10.000	1.259				

Terms — Ratios
Nominal Range Ratio = 18

18-6-A		18-11-A		18-11-C		18-21-B	
1.000	....	1.000	....	1.000	....	1.000	....
2.818	2.818	1.679	1.679	1.413	1.413	1.188	1.188
6.310	2.239	2.678	1.595	1.970	1.395	1.408	1.185
11.22	1.778	4.059	1.516	2.712	1.377	1.664	1.181
15.85	1.413	5.845	1.440	3.687	1.359	1.959	1.178
17.78	1.122	7.995	1.368	4.949	1.342	2.300	1.174
		10.39	1.300	6.558	1.325	2.693	1.171
18-6-B		12.83	1.235	8.579	1.308	3.143	1.167
1.000	....	15.06	1.173	11.08	1.292	3.656	1.163
2.512	2.512	16.79	1.115	14.13	1.275	4.241	1.160
5.309	2.114	17.79	1.059	17.79	1.259	4.905	1.156
9.441	1.778					5.655	1.153
14.13	1.496	18-11-B		18-21-A		6.500	1.149
17.78	1.259	1.000	....	1.000	....	7.448	1.146
		1.585	1.585	1.259	1.259	8.509	1.142
18-6-C		2.417	1.525	1.571	1.248	9.692	1.138
1.000	....	3.548	1.468	1.942	1.236	11.01	1.136
1.995	1.995	5.012	1.413	2.379	1.225	12.46	1.132
3.758	1.884	6.812	1.359	2.887	1.214	14.06	1.129
6.683	1.778	8.911	1.308	3.473	1.203	15.82	1.125
11.23	1.679	11.22	1.259	4.140	1.192	17.75	1.122
17.78	1.585	13.59	1.212	4.891	1.181		
		15.84	1.166	5.725	1.171		
		17.78	1.122	6.641	1.160		
				7.634	1.149		
				8.896	1.139		
				9.815	1.129		
				10.98	1.119		
				12.17	1.108		
				13.37	1.098		
				14.55	1.088		
				15.69	1.079		
				16.77	1.069		
				17.76	1.059		

Terms — Ratios
Nominal Range Ratio = 32

32-7-A		32-13-A		32-13-C		32-25-B	
1.000	....	1.000	....	1.000	....	1.000	....
2.818	2.818	1.679	1.679	1.413	1.413	1.189	1.189
6.607	2.344	2.703	1.610	1.974	1.398	1.409	1.186
12.88	1.950	4.173	1.544	2.731	1.383	1.666	1.183
20.89	1.622	6.179	1.481	3.739	1.369	1.966	1.180
28.18	1.349	8.774	1.420	5.065	1.355	2.313	1.177
31.62	1.122	11.95	1.362	6.790	1.341	2.714	1.174
		15.60	1.306	9.009	1.327	3.178	1.171
32-7-B		19.54	1.252	11.83	1.313	3.711	1.168
1.000	....	23.47	1.201	15.37	1.299	4.324	1.165
2.512	2.512	27.03	1.152	19.76	1.286	5.024	1.162
5.495	2.188	29.86	1.105	25.14	1.272	5.824	1.159
10.47	1.906	31.63	1.059	31.65	1.259	6.734	1.156
17.38	1.660					7.766	1.153
25.12	1.445	32-13-B		32-25-A		8.935	1.150
31.62	1.259	1.000	....	1.000	....	10.25	1.148
		1.585	1.585	1.259	1.259	11.74	1.145
32-7-C		2.434	1.536	1.573	1.250	13.40	1.142
1.000	....	3.623	1.488	1.951	1.240	15.26	1.139
1.995	1.995	5.226	1.442	2.401	1.231	17.34	1.136
3.802	1.906	7.305	1.398	2.934	1.222	19.66	1.133
6.918	1.820	9.895	1.355	3.557	1.213	22.22	1.130
12.02	1.738	12.99	1.313	4.281	1.204	25.06	1.127
19.95	1.660	16.52	1.272	5.114	1.195	28.18	1.125
31.62	1.585	20.37	1.233	6.062	1.186	31.62	1.123
		24.33	1.195	7.134	1.177		
		28.17	1.158	8.331	1.168		
		31.61	1.122	9.657	1.159		
				11.11	1.151		
				12.69	1.142		
				14.38	1.133		
				16.17	1.125		
				18.06	1.116		
				20.01	1.108		
				22.01	1.100		
				24.02	1.092		
				26.03	1.083		
				27.99	1.075		
				29.87	1.067		
				31.64	1.059		

$$n = \frac{\frac{3}{2}\log \rho - \log r \pm \sqrt{Z}}{\log \rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

where

$$Z = (\log r - \frac{3}{2}\log \rho)^2 - 2 \log \rho \, (\log a - \log l - \log r + \log \rho)$$

For the case under analysis here, this formula furnishes two positive roots, confirming that the curve representing the progression has two branches, both positive.

In the majority of series applications, the problem will have the last ratio r_n, and not the second order ratio ρ, included in the basic data. A general solution may be found by substituting for log ρ

Terms — Ratios
Nominal Range Ratio = 56

56-8-A		56-8-B		56-8-C		56-8-D	
1.000	....	1.000	....	1.000	....	1.000	....
2.985	2.985	2.818	2.818	2.512	2.512	1.995	1.995
7.499	2.512	6.813	2.417	5.623	2.239	3.831	1.920
15.85	2.114	14.13	2.073	11.22	1.995	7.079	1.848
28.18	1.778	25.12	1.778	19.95	1.778	12.59	1.778
42.17	1.496	38.31	1.525	31.62	1.585	21.54	1.711
53.09	1.259	50.11	1.308	44.67	1.413	35.48	1.647
56.23	1.059	56.22	1.122	56.23	1.259	56.23	1.585

56-15-A		56-15-B		56-15-C	
1.000	....	1.000	....	1.000	....
1.679	1.679	1.584	1.584	1.413	1.413
2.720	1.620	2.446	1.543	1.978	1.400
4.254	1.564	3.676	1.503	2.744	1.388
6.422	1.510	5.380	1.464	3.775	1.376
9.357	1.457	7.666	1.425	5.147	1.363
13.16	1.406	10.64	1.388	6.955	1.351
17.86	1.357	14.38	1.351	9.316	1.339
23.40	1.310	18.92	1.316	12.37	1.328
29.59	1.264	24.24	1.281	16.28	1.316
36.11	1.220	30.25	1.248	21.23	1.304
42.54	1.178	36.75	1.215	27.45	1.293
48.37	1.137	43.49	1.183	35.17	1.281
53.08	1.097	50.11	1.152	44.67	1.270
56.23	1.059	56.23	1.122	56.24	1.259

56-29-A		56-29-B
1.000	....	1.000	....
1.259	1.259	1.189	1.189
1.575	1.251	1.410	1.186
1.957	1.243	1.668	1.183
2.417	1.235	1.970	1.181
2.966	1.227	2.321	1.178
3.617	1.219	2.730	1.176
4.382	1.212	3.203	1.173
5.275	1.204	3.750	1.171
6.308	1.196	4.382	1.168
7.499	1.188	5.109	1.166
8.855	1.181	5.944	1.163
10.39	1.173	6.901	1.161
12.12	1.166	7.994	1.158
14.03	1.158	9.241	1.156
16.15	1.151	10.66	1.154
18.48	1.144	12.27	1.151
21.00	1.136	14.09	1.149
23.71	1.129	16.16	1.146
26.61	1.122	18.48	1.144
29.66	1.115	21.09	1.141
32.86	1.108	24.03	1.139
36.16	1.101	27.30	1.136
39.55	1.094	30.95	1.134
42.98	1.087	35.04	1.132
46.41	1.080	39.55	1.129
49.79	1.073	44.57	1.127
53.08	1.066	50.12	1.124
56.23	1.059	56.23	1.122

Terms — Ratios
Nominal Range Ratio = 100

100-9-A		100-9-B		100-9-C		100-9-D	
1.000	....	1.000	....	1.000	....	1.000	....
2.985	2.985	2.818	2.818	2.512	2.512	1.995	1.995
7.686	2.575	6.964	2.471	5.717	2.276	3.852	1.931
17.06	2.220	15.09	2.166	11.79	2.062	7.197	1.868
32.68	1.915	28.65	1.899	22.02	1.868	13.01	1.808
53.96	1.651	47.71	1.665	37.27	1.693	23.76	1.749
76.85	1.424	69.95	1.460	57.16	1.534	38.52	1.693
94.39	1.228	89.14	1.280	79.42	1.390	63.08	1.638
100.00	1.059	100.00	1.122	100.00	1.259	100.00	1.585

100-17-A		100-17-B		100-17-C	
1.000	....	1.000	....	1.000	....
1.679	1.679	1.585	1.585	1.413	1.413
2.733	1.628	2.455	1.549	1.980	1.402
4.315	1.579	3.715	1.514	2.754	1.391
6.607	1.531	5.495	1.479	3.802	1.380
9.810	1.485	7.943	1.445	5.208	1.370
14.13	1.440	11.23	1.413	7.080	1.359
19.72	1.369	15.49	1.380	9.552	1.349
26.72	1.354	20.89	1.349	12.79	1.339
35.08	1.313	27.54	1.318	16.99	1.328
44.63	1.274	35.48	1.288	22.40	1.318
55.17	1.235	44.67	1.259	29.27	1.308
66.10	1.198	54.95	1.230	38.04	1.298
76.78	1.162	66.07	1.202	49.01	1.288
86.49	1.126	77.62	1.175	62.66	1.279
94.48	1.092	89.12	1.148	79.50	1.269
100.00	1.059	100.00	1.122	100.00	1.259

100-33-A		100-33-B
1.000	....	1.000	....
1.259	1.259	1.188	1.188
1.576	1.252	1.410	1.186
1.962	1.245	1.669	1.184
2.429	1.238	1.973	1.182
2.991	1.231	2.328	1.180
3.662	1.224	2.741	1.178
4.458	1.218	3.222	1.175
5.398	1.211	3.779	1.173
6.500	1.204	4.426	1.171
7.782	1.197	5.173	1.169
9.266	1.191	6.034	1.167
10.97	1.184	7.027	1.164
12.92	1.177	8.168	1.162
15.13	1.171	9.476	1.160
17.62	1.164	10.97	1.158
20.40	1.158	12.68	1.156
23.49	1.152	14.63	1.154
26.90	1.145	16.85	1.152
30.63	1.139	19.37	1.149
34.69	1.132	22.22	1.147
39.07	1.126	25.45	1.145
43.75	1.120	29.31	1.143
48.72	1.114	33.19	1.141
53.96	1.107	37.79	1.139
59.43	1.101	42.96	1.137
65.09	1.095	48.74	1.135
70.89	1.089	55.20	1.132
76.78	1.083	62.39	1.130
82.70	1.077	70.40	1.128
88.57	1.071	79.28	1.126
94.34	1.065	89.12	1.124
100.00	1.059	100.00	1.122

in Equation 18 the value given in Equation 16. Solving for the number of terms n in the resulting expression and simplifying,

$$n = 2\,\frac{\log l - \log a}{\log r + \log r_n} + 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

Equation 20 is proof that the substitution for $\log \rho$ has produced a first degree expression. In view of the limiting conditions previously established, there must be only one value of n which will satisfy it. This value can fall on the first or second branch of the progression curve; in this particular case it is on the first branch where $r_n > 1$.

Reconverting logarithms to numbers in Equation 20 and solving for l results in an expression giving the value of the nth term as a function of the first term and the first and last ratios:

$$l = a[(r)(r_n)]^{(n-1)/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

Conventional Progressions: The ordinary geometrical progression may be considered as a special case of the second-order type in which $\rho = 1$ and $r = r_n = r'$ where r' is the ratio of the conventional progression and has a constant value. If one or both of these conditions is introduced in the formulas developed in the previous discussion, the expressions become suitable for use with conventional progressions.

The American Standards Association has established a set of five geometrical progressions* for use in standardization of physical or geometrical dimensions. The terms of these progressions rounded off by convention, are called preferred numbers and were first developed in 1879 by the French Colonel Charles Renard. They were adopted by the ASA during the decade preceding World War II.

Standard basic preferred numbers for a decimal series, 10 to 100, are given in *Table* 3. Properties of these numerical series are well known. For application to calculations, the most interesting properties may be summarized as:

1. Multiplication or division of two preferred numbers gives approximately a preferred number.
2. A power of a preferred number in which the exponent is an integer is also a preferred number.
3. The powers of preferred numbers in which the exponent is any number may not be preferred numbers, but they form geometrical progressions having ratios equal to the ratio of the original series elevated to the same exponent.

*American Standard Preferred Numbers—ASA Z17.1-1936 (Reaffirmed 1946)

Table 6—Alternate Series Arrangement

Term	Value	Ratio	Term	Value	Ratio
1	1.00	....	10	5.60	1.189
2	1.25	1.259	11	6.30	1.122
3	1.60	1.259	12	7.10	1.122
4	2.00	1.259	13	8.00	1.122
5	2.36	1.189	14	8.50	1.059
6	2.80	1.189	15	9.00	1.059
7	3.35	1.189	16	9.50	1.059
8	4.00	1.189	17	10.00	1.059
9	4.75	1.189			

Despite these characteristics which make preferred numbers a useful tool for many standardizing purposes, rational planning of machine lines is approached on a more fundamental level by the use of second-order progressions. To match this basic requirement with the advantageous characteristics of preferred numbers, a second-order progression may be formed and then replaced by a group of two or more fundamental or derived standard series with decreasing ratios.

Numerical Example of Progression Analysis: The second-order geometrical progression represented in *Fig.* 8 has the following characteristic data: First term $a = 2$, $\log a = 0.30103$; first ratio $r = 1.5$, $\log r = 0.17609$; second order ratio $\rho = 0.98285$, $\log \rho = 9.99249\text{-}10 = -0.00751$. It will be assumed that the data to be determined include (1) the order of the term of maximum value, (2) the term to which the progression must be extended so that the ratio r decreases from the initial value of 1.5 down to a final value established by the condition $r_n \geqq 1.08$, and (3) the terms whose values are nearest to the value of 200 in both the region of increasing values as well as in the region of decreasing values.

ORDER OF TERM OF MAXIMUM VALUE: To find the order of the term of maximum value, the limiting condition $r\rho^{n-2} > 1$ must be applied. Transforming this expression to its logarithmic form and substituting appropriate values gives a solution whose integral part is the order sought:

$$n < \frac{\log r}{-\log \rho} + 2$$

$$n < \frac{0.17609}{0.00751} + 2$$

$$n < 25.45$$

This result indicates that the desired term is the 25th of the progression. Proof that this term is actually the one of maximum value can be readily obtained by calculating the respective values of the 24th, 25th and 26th terms from Equation 18. These calculated values are $l_{24} = 282.5$, $l_{25} = 284.7$ and $l_{26} = 282.02$, clearly indicating that the 25th term, l_{25}, is the maximum.

FINAL TERM OF EXTENDED PROGRESSION: For the given limiting condition for the last ratio, $\log r_n = \log 1.08 = 0.03342$. From Equation 17,

$$n \leqq \frac{0.03342 - 0.17609}{-0.00751} + 2$$

$$n \leqq 21.1$$

This result means that the ratio to be applied to the 20th term to obtain the 21st is greater than 1.08 and that the ratio to be applied to the 21st term to find the 22nd is less than 1.08. Thus, the progression sought must have 21 terms.

TERMS OF CORRESPONDING VALUE: The possibility that there are two terms having values near 200, one in a region of increasing values and the other in a region of decreasing values, is suggested upon consideration of the calculation results obtained in the first part of this example. The basis for this conclusion is merely the fact that the desired value of 200 is less than the calculated maximum term value of 284.7. The two terms sought may be found by means of Equation 19. Substituting appropriate values in the equation gives two solutions $n = 18.6$ and $n' = 31.4$. These values are indicated by points A and B on the curve in *Fig.* 8. From these calculated results and from the shape of the curve in *Fig.* 8, or from the sign of the derivative of the function if the curve has not been plotted, it can be determined that the 18th and 32nd terms, taking the integer term numbers immediately preceding and following the respective decimal numbers found, have values < 200. These terms are shown as points A' and B' in *Fig.* 8. The terms having values > 200 would be those following the 19th and preceding the 31st terms, points A'' and B'' in *Fig.* 8.

Important Progression Properties: The following discussion summarizes the properties of progressions having the greatest significance in the development of machine series. These characteristics are generally applicable to both types of progressions, conventional and second-order. Properties applicable to only one type of progression will be separately indicated. In this summary the exponent of ρ defined by Equations 11 and 12 will be denoted by the symbol Σ.

1. If the terms of a progression are multiplied by a constant factor, another progression is obtained which has a first term equal to the first term of the original progression multiplied by the constant factor and ratios equal to those of the original progression. Thus, if m is the multiplying factor for a second-order progression, from Equation 13,

$$l\,m = a\,m\,r^{n-1}\,\rho^{\Sigma} \qquad (22)$$

This same operation can also be used for conventional progressions, in which case $\rho = 1$.

2. If a progression is multiplied, term by term, by a second progression having an equal number of terms, the result is a progression which has a first term and ratios equal to the products of the first terms and ratios of the original progressions. Assuming two progressions with equal numbers of terms are

$$l_1 = a_1\,r_1^{n-1}\,\rho_1^{\Sigma}, \quad l_2 = a_2\,r_2^{n-1}\,\rho_2^{\Sigma}$$

then

$$l_1\,l_2 = a_1\,a_2\,(r_1\,r_2)^{n-1}\,(\rho_1\,\rho_2)^{\Sigma} \qquad (23)$$

As in the foregoing case, this property also holds for conventional progressions where the second order ratios ρ_1 and ρ_2 are both equal to 1.

3. If all the terms of a progression are raised to a power of any exponential value, the result is a progression with first term and ratios equal to those of the original progression raised to same power. Thus, for a second-order progression raised to a power p,

$$l^p = a^p\,r^{p(n-1)}\,\rho^{p\Sigma} \qquad (24)$$

This property also applies to conventional progressions.

4. Division of a progression, term by term, by a second progression having an equal number of terms gives a result corresponding to that obtained for multiplication of the progressions. For the two equal-order progressions in Equation 23, it follows that

$$\frac{l_1}{l_2} = \frac{a_1}{a_2}\left(\frac{r_1}{r_2}\right)^{n-1}\left(\frac{\rho_1}{\rho_2}\right)^{\Sigma} \qquad (25)$$

5. If two progressions of different order, one of second-order and the other conventional, are multiplied together term by term a second-order progression is obtained. The resulting progression has a first term and first ratio equal to the products of the first terms and first ratios of the original progressions; however, the second-order ratio is equal to the second-order ratio of the original second-order progression. Assuming two progressions of different order to be

$$l_1 = a_1\,r_1^{n-1}\,\rho_1^{\Sigma}, \quad l_2 = a_2\,r_2^{n-1}$$

then

$$l_1\,l_2 = a_1\,a_2\,(r_1\,r_2)^{n-1}\,\rho_1^{\Sigma} \qquad (26)$$

6. Division of progressions of different order also produces a second-order progression. The resulting progression corresponds to that obtained by multiplication, if the second-order progression is employed as the dividend. For the progressions in Equation 26, this operation gives

$$\frac{l_1}{l_2} = \frac{a_1}{a_2}\left(\frac{r_1}{r_2}\right)^{n-1}\rho_1^{\Sigma} \qquad (27)$$

However, if the second-order progression is the divisor, the second order ratio of the resulting progression is equal to the reciprocal of the second-order ratio of the original second-order progression. In equation form,

$$\frac{l_2}{l_1} = \frac{a_2}{a_1}\left(\frac{r_2}{r_1}\right)^{n-1}\frac{1}{\rho_1^{\Sigma}} \qquad (28)$$

7. If the terms of a conventional progression, which is defined by the limiting term values a and l, are multiplied by the ratio l/a, the result is a progression, having the same ratio, with a first term equal to the last term of the original progression. Thus, the resulting progression is a continuation of the original and has an equal number of terms. This property is essentially a corollary of the first

property discussed; however, the fact that the new progression is a continuation of the original only applies to conventional progressions and not to those of the second order. For proof of this qualification, it is only necessary to remember that if this operation were applied to second-order progressions, the new series of ratios would begin with the first ratio of the original progression and each succeeding ratio would be repeated in the new progression. Consequently, the new progression would not be a continuation of the original.

Planned Progressions: Collected in *Tables* 4 and 5 are a number of second order progressions which, due to the criteria used for their development, offer a basis for preliminary series planning and represent an initial rational grouping, arranged to facilitate application in the tracing of machine lines. To aid understanding of the use of the tables, these underlying concepts and their significance are treated in detail in the following discussion.

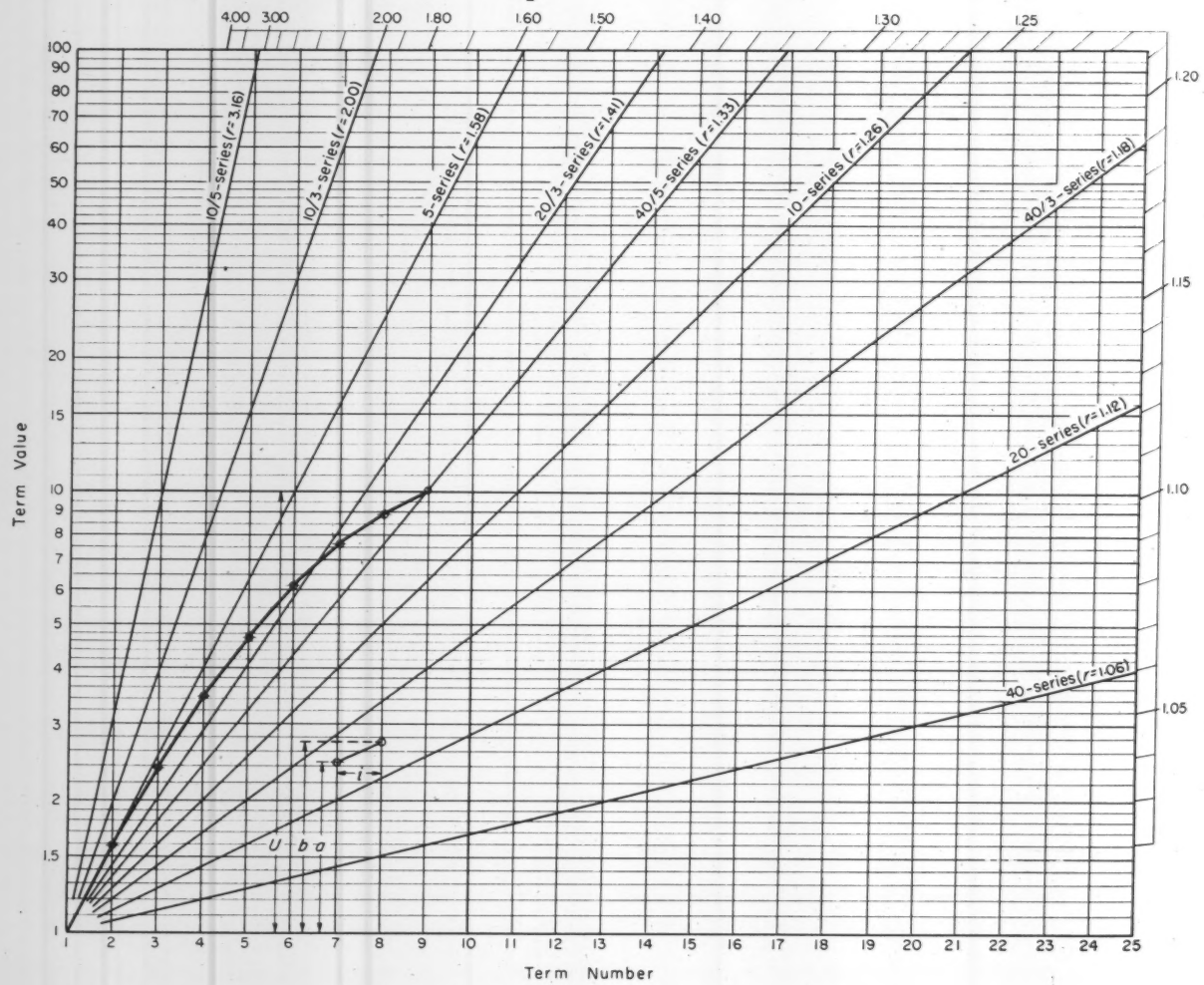
In these tables, ratios between limiting progression terms, numbers of terms, and the relationship of these two quantities have been established in accordance with the requirements most frequently encountered in the tracing of series of operational and geometrical modules.

As to the permissible ranges of progression ratio variation, it must be pointed out that in any second-order progression the limiting ratios r and r_n cannot be independently selected, but must obey the condition derived from the limiting conditions mentioned previously and defined by Equation 20 which, when transformed, gives

$$\log r + \log r_n = 2\,\frac{\log l - \log a}{n - 1}$$

In any progression of this kind in which values of the limiting terms and the number of terms are given, the limiting ratios may be selected with

Fig. 9—Semilogarithmic chart for analysis of progression terms. Straight line plots represent standard preferred numbers series and broken-line curve illustrates typical plot for a second-order progression



some freedom as long as they are mutually compensating. If one ratio increases in value, the other must decrease to maintain the sum of their logarithms at a constant value. The second order ratio ρ is dependent on the selected pair of limiting ratios and on the difference of their logarithms, Equation 16.

It is interesting to note that the geometrical mean of the limiting ratios is also the ratio (constant) of a conventional geometrical progression which has the same number of terms and the same limiting term values. As a matter of fact, through use of the relationship $r = r_n = r'$, where r' is the ratio of a conventional progression, in combination with Equation 20, the following result is obtained:

$$\frac{\log r + \log r_n}{2} = \log r'$$

Reconverting the logarithmic expression to numerical form gives the geometrical mean,

$$\sqrt{r\,r_n} = r' \qquad (29)$$

A general standardization of second-order progressions is not feasible because of two concurrent circumstances: (1) Second-order progressions of decreasing ratio are not unlimited, as ordinary progressions may be, since the term values grow to a maximum and then decrease; (2) to standardize conventional progressions, it is sufficient to choose, on the basis of the particular rational criteria, the limiting values and a set of ratios. For second-order progressions selection would have to be made within the fourfold infinity of their characteristics including the ratio between limiting terms, initial ratio, second-order ratio and number of terms.

Thus, the different series given in *Tables* 4 and 5 do not and can not constitute a standardization in the recognized sense of the word, but rather are merely a group of series arrangements, planned on the basis of practical design requirements and a codification limited to the very definite objective of these articles.

In *Table* 4, the basic data of each series have been collected; ratio between limiting terms and first, last, and second order ratios. In *Table* 5 values of terms and ratios for each particular progression are given.

In planning these tabulated progressions, the following criteria have been adopted. The ranges, which are represented by the ratios between the values of the limiting terms (first number of the identifying symbol), have been fixed in such a way as to coincide with the requirements in practice of the dimensional modules of machine lines. Care has been taken to keep the logarithm of the ratio between limiting values, $\log l - \log a$, which is often used in calculations, in terms of simple numbers; 0.75, 1.00, 1.25, etc. For each one of these ranges, three different numbers of terms (second number of the identifying symbol) have been fixed. For each one of the latter, a certain number of pairs of limiting ratios of values, such that their logarithms coincide with the logarithms of the ratios of the series of preferred numbers, have been used. These precautions make possible the eventual extension of these planned progressions with some terms of the series of preferred numbers.

The result is a group of 48 planned second-order progressions among which it will be easy to find one that fits a particular case, as will be shown by examples in the succeeding articles of this series.

The paths that have been followed to derive these planned series are far from being the only ones possible. Other possible criteria might include: (1) Make ratio between limiting term values equal to 10 and constant in all series, (2) make number of intervals equal to 5, 10, 20, and 40 as in preferred number series, and (3) for each number of terms establish a certain group of limiting term ratios as in each group of the planned series in *Tables* 4 and 5.

The planned progressions presented here, are not, in the manner of preferred numbers, sets of numbers to be adopted without modification to maintain their known advantages, but are only guides for the rational planning of series. Therefore, it is permissible, and often advisable, to derive other series from the planned progressions by multiplying the terms by any constant number. For example, suppose the modules represented by the numbers 40 and 400 must be joined by a series of 9 terms. Since the ratio between limiting terms is 10, and the number of terms is 9, one of the planned progressions, 10-9-A, 10-9-B or 10-9-C may be chosen. Selecting the first of these and multiplying its terms by 40 furnishes the following series: 40, 63.40, 95.64, 137.32, 187.72, 244.20, 302.44, 356.48, 400. Rounding off terms, the series becomes: 40, 63, 96, 137, 188, 244, 302, 356, 400.

Another possible operation, also justified by the foregoing reasons, substantially extends the field of application of these progressions. This operation involves the raising of the terms of a progression to a power of any positive exponential value, whole or fractional. The progression thus derived will have first and last terms and ratios equal to those of the original progression elevated to the same power. This technique provides an extension of the field covered by the original series

Table 7—Ratios of Natural Numbers

Number	Ratio	Number	Ratio	Number	Ratio
1	.....	8	1.1428	15	1.0714
2	2.0000	9	1.1250	16	1.0667
3	1.5000	10	1.1111	17	1.0625
4	1.3333	11	1.1000	18	1.0588
5	1.2500	12	1.0909	19	1.0556
6	1.2000	13	1.0833	20	1.0526
7	1.1667	14	1.0769		

and, if properly applied, also gives limiting ratios different from those fixed in the tables.

For example, assume it is required to plan a series of modules having the following characteristics: First term, $a = 5$; last term, $l = 160$; term number, $n = 5$; first ratio, $r = 4$; and last ratio, $r_n = 1.4$. The ratio between the limiting terms, $l/a = 32$, corresponds to one of the ratio groupings of *Tables* 4 and 5. However, none of the progressions of the "32-5" set fit the other given data. To find a solution, it will be necessary to use the 10-5-A series. If the terms of this series are raised to the 3/2 power, the following results are obtained: $l/a = 10^{1.5} = 31.6$, $r = 2.51^{1.5} = 3.98$ and $r_n = 1.26^{1.5} = 1.41$. These values are, for all practical purposes, sufficiently near the given data. The series derived by raising the terms of the 10-5-A series to the 3/2 power is: 1, 3.98, 11.22, 22.38, 31.6. Multiplying these terms by 5 gives the desired series: 5, 19.9, 56.1, 111.9, 158.1. First and last ratios for this series are $r = 3.98$ and $r_n = 1.41$.

As mentioned earlier, in certain cases a second-order progression may be replaced by a group of ordinary progressions, generally chosen from among the preferred number series.

Suppose, for example, there is a machine line whose modules follow the planned second order progression, 10-17-A. This progression may be replaced by a combination of the standard preferred number series given in *Table* 3. Term values are determined as follows: For the region 1.00 to 2.00, four terms from the 10-series; for the region 2.00 to 5.60, six terms from the 40/3-series (every third term of the 40-series); for the region 5.60 to 8.00, 3 terms from the 20 series; and for the region 8.00 to 10.00 four terms from the 40-series.

The series thus obtained, which has a total number of 17 terms and limiting ratios r and r_n equal to the corresponding ratios of the original second order series, is given in *Table* 6.

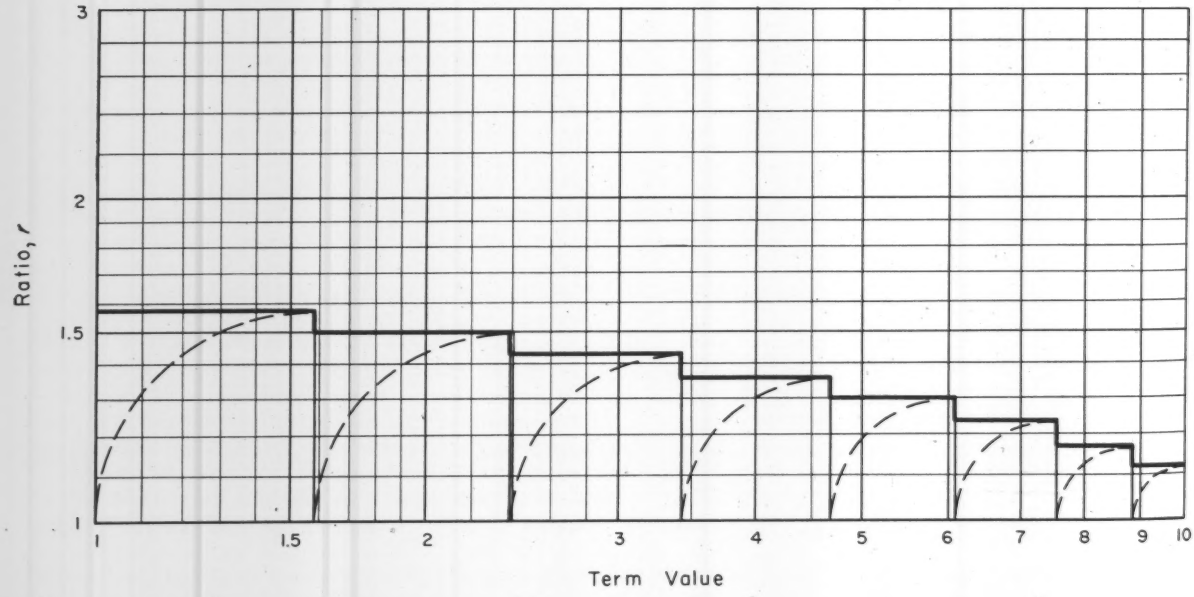
In general, such a substitution can only be made when the number of terms is sufficiently great with respect to the ratio. If the number of terms is small, less than 10, or the ratios are great, it is more convenient to adopt the second-order progression.

Higher Order Progressions: Based on the same line of reasoning which led to the development of the second-order progression from conventional types, a third-order progression is also feasible. In this type of progression, the ratio ρ, instead of remaining constant as in second-order progressions would vary in the same manner as the terms of a conventional geometrical progression. Similarly, it is evident that progressions of any order superior to the second are possible.

Since the aim of these articles is far from being one of mathematical philosophy, it will be sufficient to point out that such higher-order progressions might have application in planning extensive series of operational modules such as those with total ratios around 1/1000, particularly when commercial criteria indicate the convenience of having high initial ratios which decrease rapidly along the first region of the series and more slowly in the succeeding term zones.

As in the case where second-order progression is replaced by combinations of preferred number series, the purpose of third or higher-order progressions may often be served by a combination of two or more subsequent second-order progressions

Fig. 10—Logarithmic chart, with typical curve plot, for analysis of progression ratios



which have the same ratio for overlapping terms as well as second-order ratios increasing from one to the other; that is, coming nearer to unity to provide the desired "deceleration" of the ratios of the final progression. In the subsequent articles dealing with specific problems, some interesting uses of this procedure will be demonstrated.

Arithmetic Progressions: The deceptive simplicity of arithmetic progressions has often led to their adoption in the planning of a series of modules. This usage is perhaps responsible for the incongruities in many existing machine lines. Nevertheless, there are some cases in which the arithmetic progression must be used; for example, when a line of internal combustion engines is comprised of assemblies having increasing numbers of equivalent cylinders. For this application, the arithmetic progression takes its simplest form and is proportional to the series of integers formed between the two limiting values established by the minimum and maximum number of cylinders of the engines.

Although it is true that the ratio between subsequent terms of an arithmetical progression is gradually decreasing and may in certain cases give the appearance of a rational arrangement, as pointed out in Part 1 this decrease occurs at a rate that is acceptable only for a limited range of machine series terms.

Because of the inherent irrationality of arithmetic progressions for machine series planning, consideration will be limited to the ratios between terms of the series of natural numbers from 1 to 20. These values, which are the limits of application of this progression in practice, are given in *Table* 7.

Application of Progressions: The main objective in tracing a machine series is to obtain a family of machines in which the most important operational characteristics are arranged according to a plan or rational scale. Fulfillment of this objective is achieved through a systematic arrangement of the different machines of the group according to their size. Thus, a planned series of geometrical modules must be established if a rational planned series of operational modules is to be obtained.

The planning operation is greatly simplified if a relationship can be found between both modules where the analytical form of the relationship is such that it directly relates not only the modules, but also all the characteristics of the respective series. In the majority of cases, this relationship, which will be treated in detail in the articles to follow, takes the general form given by Equation 1 in Part 1. The feasibility of using this expression in all practical applications has a fundamental influence on the selection of the most suitable type of mathematical series and justifies the preference for second-order progressions as compared to the various other possible progressions with a decreasing ratio.

From the properties of second order progressions discussed previously, it will be found that

PLANNING MACHINE SERIES

if the geometrical module L is arranged according to such a progression, with a first term a_L and ratios r_L and ρ_L, the corresponding operational module will follow a progression of the same kind, having for its first term, $a_W = k\, a_L^{\varepsilon}$, and for its ratios, $r_W = r_L^{\varepsilon}$ and $\rho_W = \rho_L^{\varepsilon}$. Conversely, if the progression of operational modules is to have a first term equal to a_W and ratios r_W and ρ_W, it is necessary and sufficient that the series of geometrical modules have a first term, $a_L = a_W^{1/\varepsilon}/k$ and ratios, $r_L = r_W^{1/\varepsilon}$ and $\rho_L = \rho_W^{1/\varepsilon}$.

A typical example of the application of these principles is furnished by a problem concerning a line of centrifugal fans in which all models operate at a constant speed of 1000 rpm. For this line of fans, the significant relationships, expressed in terms of the impeller outside diameter (geometrical module), are:

$$Q = 0.9\, D^3$$

$$p = \frac{D^2}{126}$$

$$P = \frac{D^5}{534{,}000}$$

where Q = air volume in cfm, p = total gage pressure in inches of water, P = power input in hp based on a constant total efficiency of 60 per cent and D = impeller outside diameter in inches. The problem is to determine the ratios for the series of outside diameter dimensions if the volumes follow a progression with ratios $r_Q = 1.8$ and $\rho_Q = 0.98$.

From the relationships given, it can be seen that $r_Q = r_D^3$ and $\rho_Q = \rho_D^3$. Thus

$$r_D = \sqrt[3]{r_Q} = \sqrt[3]{1.8} \approx 1.22$$

$$\rho_D = \sqrt[3]{\rho_Q} = \sqrt[3]{0.98} \approx 0.993$$

For the progression of pressures, the ratios are,

$$r_p = r_D^2 = 1.22^2 \approx 1.48$$

$$\rho_p = \rho_D^2 = 0.993^2 \approx 0.986$$

And for input power,

$$r_P = r_D^5 = 1.22^5 \approx 2.7$$

$$\rho_P = \rho_D^5 = 0.993^5 \approx 0.886$$

Graphical Series Representation: More than a mere numerical development for which analytical procedures might be better adapted, the graphical representation of a series must synthesize the general characteristics of the series to be studied, clearly indicating any existing ratio variations as well as the form of such variation.

The first objective is achieved by means of a semilogarithmic chart* in which the abscissas represent the terms of the series, spaced along a

* O. Kienzle—"Preferred Numbers and Their Application," *Zeitschrift des Vereines Deutscher Ingenieure*, No. 24, 1939.

scale with uniform intervals, and the ordinates give the values of those terms on a logarithmic scale, *Fig.* 9. It is easy to prove that in such a diagram ordinary geometrical progressions appear as straight lines with slopes proportional to the series ratio.

In *Fig.* 9 if a and b are the values of two consecutive series terms, U represents the logarithmic unity scale of the ordinates and i is the distance, along the abscissa, between the representative term points, the slope, m, of the straight line connecting the points is given by the expression

$$m = \frac{U\ (\log b - \log a)}{i} = \frac{U}{i} \log \left(\frac{b}{a} \right) \quad \ldots . (30)$$

As in conventional geometrical progressions, the ratio b/a and the slope of all segments connecting the term points are constants. Thus, all of the representative term points of the series are situated on a straight line. Since U and i are constants, the slope of this line is proportional to b/a which is the ratio of the progression.

To make the original Kienzle's chart more complete, a goniometric scale with its center in the origin of axes has been added to the chart in *Fig.* 9. This addition makes possible the plotting of curves according to specific ratios and permits direct measurement of the ratio of plotted progression. The curves given in *Fig.* 9 represent the basic standard preferred number series as well as the derived series of most frequent use.

It is evident that if the series ratio varies along the series instead of remaining constant, the points will fall on a broken line which is concave with relation to the abscissas if the ratio decreases and convex if it increases. Thus, this chart provides an efficient method for series synthesis and indicates if the ratio is constant or variable. However, it does not give sufficient evidence as to the value and importance of the ratio variations or numerical values. If, for example, one or more ratios have abnormal values, being larger than the preceding one and smaller than the following, these irregularities may not be sufficiently apparent because they are graphically represented only by the slope variation of the segments of a broken line.

To make up for these deficiencies, the chart in *Fig.* 9 has been combined with another so as to give clearer indication of the variations of the ratio, *Fig.* 10.

In using this chart, the values of the terms of a series are plotted along the abscissas in logarithmic scale. At each term value point a vertical line is then drawn to a height equal to the distance between that point and the preceding one. Horizontal lines are then drawn to complete the squares between the ordinates and abscissas thus defined. As a result of this procedure, the ordinates show the ratios between subsequent abscissas; that is, the ratios between the terms represented by these abscissas. Variations of successive ratios become more evident since they are represented by the sides of squares in mutual contact, and not, as in the preceding chart, by the slopes of segments of a broken line.

These two diagrams are known as the term value chart, *Fig.* 9, and the ratio chart *Fig.* 10. On both, the real value of the terms may be expressed by their measure on a unity scale. If necessary the scale may be multiplied by the most suitable power of 10. The first term may be made to coincide with the origin by dividing the values of all the terms by the first.

In *Fig.* 10, the ordinates have been limited to the value 3 which is the practical maximum limit of the ratios of series of geometrical modules. In some exceptional cases where this value has to be exceeded, the same diagram may be readily reproduced in logarithmic form on extended scales to provide the desired chart values.

Problem Techniques: In these first two articles, the fundamental principles and techniques of a general rational approach to machine series planning have been presented. The next and following articles of this series will deal with the application of these basic concepts in solving design problems. Specific machine types will be analyzed and methods of attack demonstrated.

They Say . . .

"It is a striking fact that seventy thousand scientists and fifty-five thousand engineers, or a total of one hundred and twenty five thousand men and women, carry the research load of the United States. Of this total about sixty per cent are in private industry, thirty-three per cent in government, and about seven per cent in universities and nonprofit institutions. This is an exceedingly small fraction of our total working population, and its smallness points up the importance, first of preserving an atmosphere and environment in which this group can be supremely effective, and second, of making certain that we maintain a steady flow of first rate minds to the group."—DR. LEWIS K. SILLCOX, *president, ASME.*

"The time lag between the acquisition of new scientific knowledge and its application to useful ends is now so short that the rate of our technological progress is largely determined by the amount of our fundamental research effort. Our dependence upon fundamental research, since it yields intangibles, is easily forgotten. Thus it needs the encouragement and support of enlightened groups in schools and colleges as well as in scientific and professional societies."—DR. WILLIAM D. COOLIDGE, *retired vice-president and director of research, The General Electic Co.*

MACHINE DESIGN
Data Sheet

GRAPHICAL METHOD SPEEDS DESIGN OF Right-Angle Helical Gears

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AN EXACT mathematical method for solving right-angle helical gear problems has been presented by Saari*. By combining the conventional design methods and relationships of right-angle helical gears, *Fig.* 1, Saari developed what might be termed the fundamental equation of right-angle helical gearing:

$$\sec \psi_1 + K \operatorname{cosec} \psi_1 = A \quad \ldots\ldots (1)$$

where A is a symbol for the relationship among diametral pitch, center distance, and number of teeth in the smaller gear:

$$A = \frac{2 P_n C}{N_1} \quad \ldots\ldots (2)$$

*Oliver Saari—"Designing Right-Angle Helical Gears," MACHINE DESIGN, July 1953, Pages 145-148.

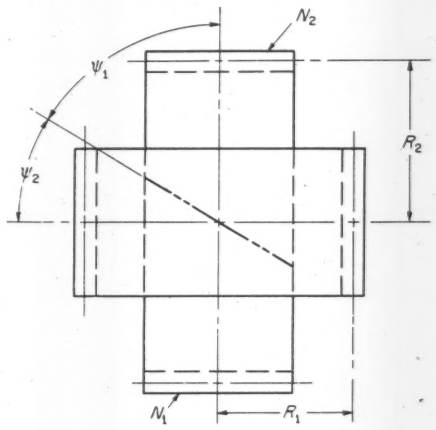


Fig. 1—Relationship of helix angles in right-angle helical gears

Simplified Approach: The solution of Equation 1 becomes somewhat difficult by mathematical means for a fixed center distance situation. Saari greatly simplified the equation solution, but where a quick close approximation is sufficiently accurate, the following method may be employed.

PROBLEM: Find the value of ψ_1 in Equation 1 if c, K, P_n, and N_1 are given.

GENERALIZED SOLUTION STEPS: 1. Determine tan $\psi_{1\,\min}$, $A_{\min}$, and $N_{1\,\max}$ by the following limit equations*:

$$\tan \psi_{1\min} = \sqrt[3]{K} \quad \ldots\ldots (3)$$

$$A_{\min} = \sec^3 \psi_{1\min} \quad \ldots\ldots (4)$$

$$N_{1\,\max} = \frac{2 P_n C}{A_{\min}} \quad \ldots\ldots (5)$$

2. Calculate A from Equation 2.

3. On a plain sheet of paper draw a circle with diameter, A.

4. Draw any diameter line across circle and mark ends a and b.

5. Using a sheet of semitransparent graph paper

Nomenclature

C = Center distance, in.
K = Desired speed ratio = N_2/N_1
N_1 = Number of teeth in small gear
N_2 = Number of teeth in large gear
P_n = Normal diametral pitch
R_1 = Pitch radius of small gear, in.
R_2 = Pitch radius of large gear, in.
ψ_1 = Pitch helix angle of small gear, deg
ψ_2 = Pitch helix angle of large gear, deg

GEARING

DATA SHEET

with 1-inch squares, draw a line parallel to one edge at a distance 1 inch away, label *P'P*, and mark with *K* values as shown in *Fig.* 2.

6. As accurately as possible, mark given *K* value on line *P'P*.

7. Place graph paper over circle layout so point *O* lies on the circle when *K* value lies on the diametral line *ab* and, at the same time, side *OX* passes over point *a* and side *OY* passes over point *b*, *Fig.* 3. Since there are two possible solutions, select the one which provides the best ratio for the given gears.

8. Angle *Oab* equals the gear helix angle ψ_1 which can be determined by measuring distance *Oa* and substituting in

$$\psi_1 = \tan^{-1} \frac{K}{(O_a) - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Finding the value ψ_1 permits the solution of Equation 1. Proof of method is covered in *Fig.* 4.

9. Check accuracy of method by comparing *A* value from Equation 1 and *A* value from Equation 2.

10. Interchange circle and graph paper positions and find the other value of ψ_1.

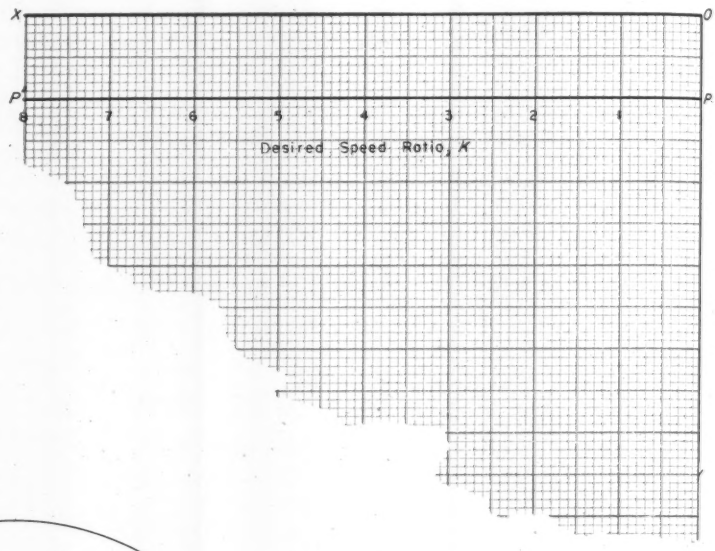


Fig. 2 — Graph paper overlay for helical gear problem solution

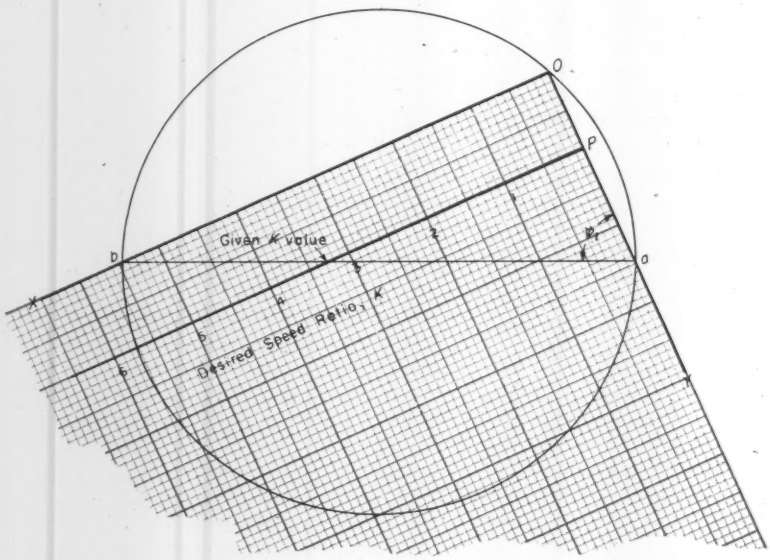


Fig. 3—Typical positioning of *Fig.* 2 chart over *Fig.* 1 for determining pitch helix angle of small gear

Fig. 4—Proof that semigraphical solution method determines helix gear angle ψ_1. Proper positioning of graph paper chart creates trigonometric relationships among sides and angles which permit diameter A to be divided into two sections, sec ψ_1 and K cosec ψ_1

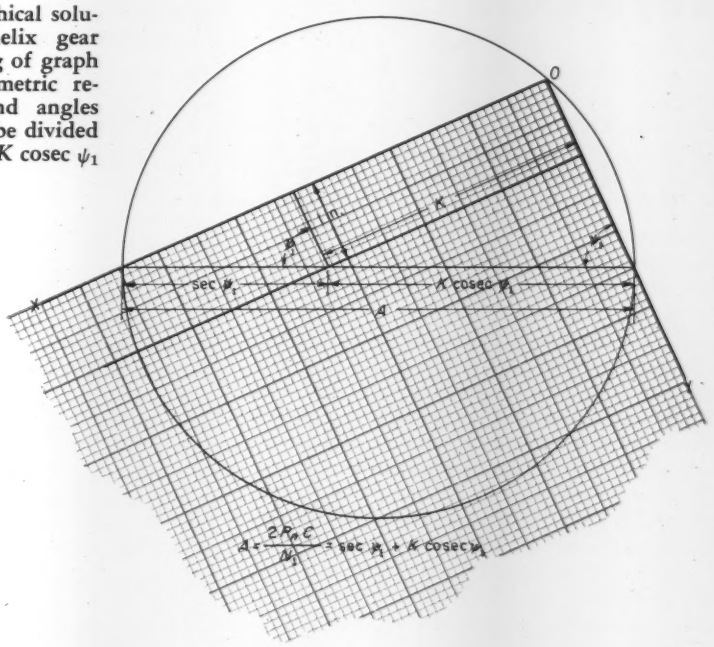
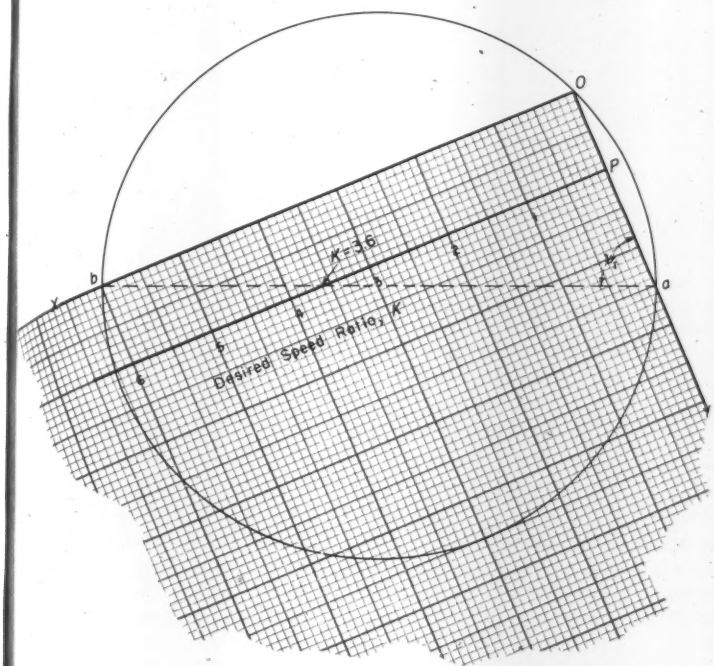


Fig. 5—Below—Graphical part of solution employing simplified approach for right-angle helical gear example problem



EXAMPLE: For a right-angle helical gear problem where $P_n = 20$, $C = 3.250$ inches, $K = 3.6$, and $N_1 = 20$, find pitch helix angle ψ of small gear.

Using Equation 3 of Step 1 under the generalized solution procedure gives a value for $\tan \psi_{1\,min} = \sqrt{3.6} = 1.532$, and thus $\psi_{1\,min} = 56$ deg 12 min. From Equation 4, the value of $A_{min} = \sec^3 56$ deg 52 min $= 6.11$ which permits the calculation of $N_{1\,max}$ from Equation 5. Thus $N_{1\,max} = 2\,(3.25)\,(20)/6.11 = 21.29$. From Step 2 using Equation 2, $A = 2\,(3.25)\,(20)/20 = 6.50$. Applying Steps 3 through 7 results in positioning the graph-paper chart and circle as shown at left. By measuring side Oa and substituting in Equation 6 of Step 8, the value of $\psi_1 = \tan^{-1} 3.6/1.48 = 2.432$. Thus $\psi_1 = 67$ deg 39 min which substituted in Equation 1 shows $A = 2.63 + 3.848 = 6.478$. Per cent error from Equation 2 value of A is $100\,(6.5 - 6.478)/65 = 0.338$ per cent.

PROFESSIONAL VIEWPOINTS

. . . standard limits and fits

A symposium of attitudes toward the ABC proposal on standardized limits and fits—and its adoption as an American Standard—was presented in the March issue of MACHINE DESIGN. Here is another discussion of that question—ED.

To the Editor:

Within the past two years a joint standards committee was formed at the American Machine and Foundry Co., dedicated to develop by evolution standards suitable to its widespread plants and engineering departments.

One of the first standards adopted was that on shaft and hole tolerances. It has definitely been shown that savings have been realized far in excess of the effort put forth to establish this standard. The savings were made by reduction in tool inventory, simplified quality control, ease of assembly, disassembly and interchangeability.

With these desired results in mind, the joint standards committee reviewed the old ASA, ISO and other standards. This review determined which classes of fits and methods of delineation would be best suited to our facilities:

1. With the exception of the loose class, use the basic hole system in order to derive the maximum benefit in manufacturing and inspection.
2. Use unilateral limiting dimensions to reduce the probability of manufacturing errors.
3. Reduce to a minimum the number of classes of fits that would become standard and still satisfy the need of our facilities.

We selected five classes of fits:

1. *Loose Fit*: Hole limits based on the economical production of a hole with a smooth finish and the alignment, parallelism and squareness of a reamed hole; shaft limits based on commercial shafting tolerances. This combination of limits provides a basic shaft series of fits. The need for deviating from the basic hole system is outlined in ISA Bulletin No. 25. This is presented by the International Federation of the National Standards Association and is used for the other four AMF series of fits. It is predicated upon the desire to provide a loose fit with a reamed hole that may be used in conjunction with cold-rolled shafting. Fits of this type are used for set-screw collars, split hubs, etc. This class of fits allows for the maximum economy of manufacture.

2. *Free Fit*: ISO hole limits grade H8 and shaft limits grade e7. These are running fits for speeds of 600 rpm or over and journal pressures of 600 psi or over. The H8 series of hole limits is also used for impregnated bearings.

3. *Medium Fit*: ISO hole limits grade H8 and shaft limits grade f6. These are running fits for speeds under 600 rpm and with journal pressures of less than 600 psi. This class of fits is also used for sliding fits and for machine tool fits.

4. *Snug Fit*: ISO hole limits grade H6 and the shaft limits of grade g5. This combination provides the closest fit that may be assembled by hand economically. Producing this fit requires precision work. This fit should be used only where no perceptible shake is permitted and the parts are not expected to move freely under load.

5. *Medium Free Fit*: ISO hole limits grade H6 and the shaft limits of grade n5 for nominal sizes 3/16 to 1½ and p5 from 1 9/16 to 4-inch diameter inclusive. Considerable pressure is required to assemble these fits and the parts may be considered permanently assembled. This class is to be used for shrink fits on parts of medium section or long fits. This is the tightest class recommended for cast iron holes or external members.

In comparison with the proposed ABC standard we are using only two classes for holes, H6 and H8, while ABC proposes 57 classes. On shafts we use only five classes: e7, f6, g5, n4, and p5, while ABC lists 66 classes. While it is true that a national standard must cover the needs of all interested industries and must comprise many more classes than are used by the average manufacturing concern, it is hoped that the number of classes will be considerably reduced before a standard is approved and issued by ASA.

As an alternate suggestion, these 57 classes of holes and 66 classes of shafts might be broken down to a series with a limited number of classes for different types of industries. We might then have separate series for the machine tool industry, ship building, precision equipment, etc., accomplishing two of the basic requirements:

1. Standardize limits and fits within certain classes of industries.
2. Reduce the number of classes that any one industry need consider.

In order to establish standards of this type on a national level some of the more important elements would have to be minutely examined:

1. Type of product.
2. Engineering and manufacturing facilities.
3. The basic requirements of the industry.
4. Interindustry demands.
5. Unification of principles such as basic hole or shaft system, bilateral or unilateral tolerances, materials, speeds, bearing loads, length of engagement, surface finish and inspection.

The difficulties of implementing a standardization procedure with a single company are evident and apparently only the very highly engineered organizations appear to be cognizant of the immediate economic gains and product improvements that are possible. Agreement in the adoption of ABC standards may only be reached if all participants feel that it represents a logical and economic approach. This result can only be obtained if a practical down-to-earth standard is established and its general use not too complicated.

JAY H. BERGEN
Chairman, Joint Standards Committee
American Machine and Foundry Co.

Engineering News Roundup

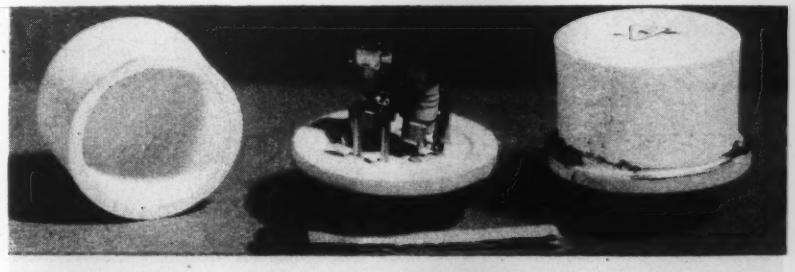
Average Starting Wages Lower for New Engineers

After spiraling for more than 10 years, average starting salaries of engineering graduates are leveling off. According to a survey made by Illinois Institute of Technology, engineering students graduating in June, 1954, are earning an average salary of $363 per month, only $1 more than the June, 1953, graduates. Starting salaries of January 1954 engineering graduates averaged $373 per month. (MACHINE DESIGN, April, 1954, Page 199).

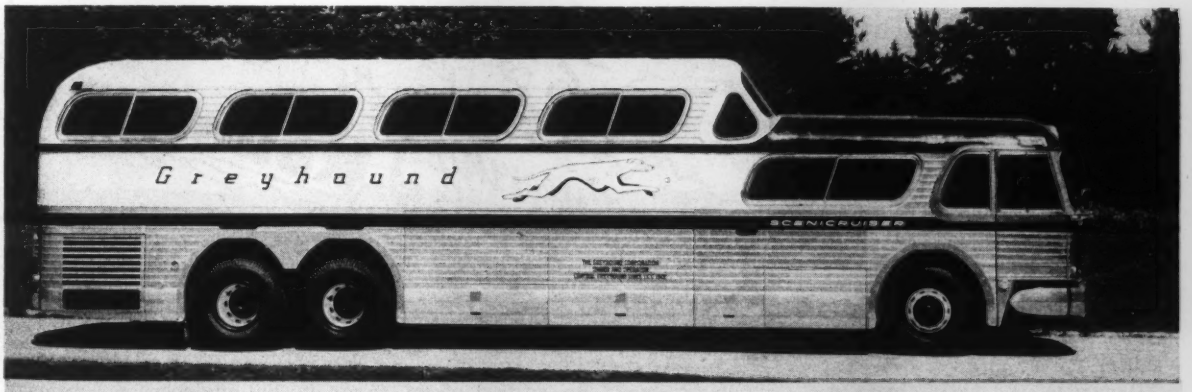
This $10 drop in average salaries is said to indicate a leveling off rather than a recession according to business leaders and educators.

Electrical engineering graduates received the most lucrative starting salaries this June, averaging $390 a month. They are receiving $1 less per month than June, 1953, graduates, but $23 more per month than January, 1954, graduates.

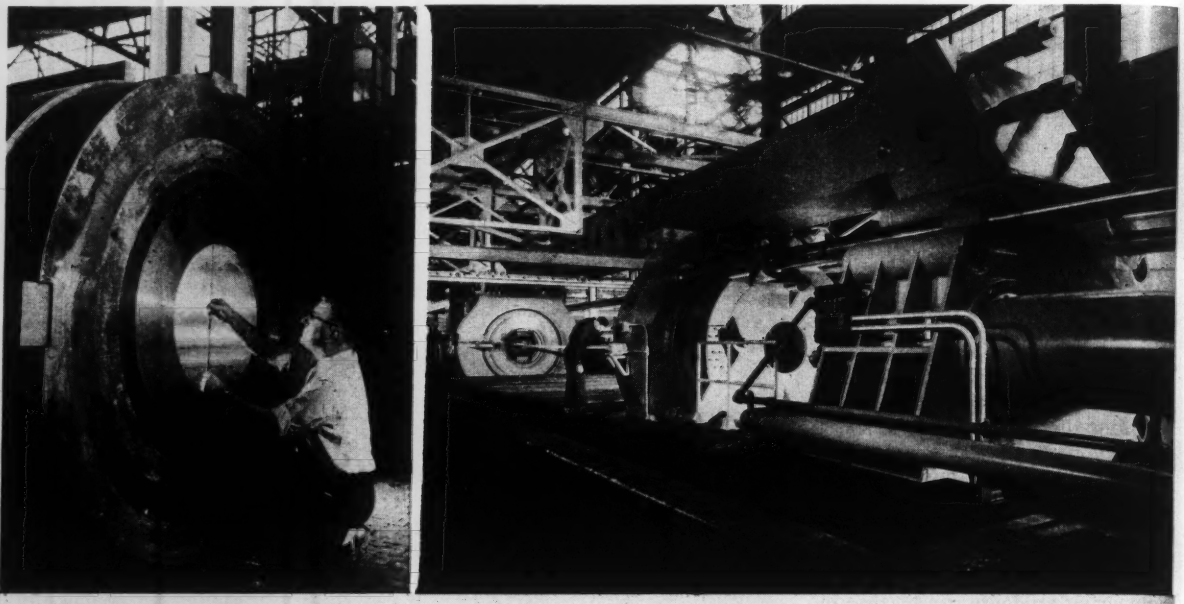
Average salaries in some of the other engineering fields in 1953 and 1954, with the 1954 figures listed first, are: civil, $348 ($367); chem-



WELL STACKED is this newly designed electron tube developed by Sylvania Electric Products Inc. Tube components are stacked by automatic production methods, said to facilitate production and produce a more compact and rugged unit



SCENICRUISER, a new luxury motor coach is being built by General Motors Truck and Coach Div. for Greyhound. This air-conditioned 43-passenger coach gives riders excellent vision from an elevated rear deck above the level of passing traffic. Two 4-cylinder 150-hp diesel engines power the bus through two fluid couplings. Should one engine fail, manual operation of the fluid coupling by the driver will permit the other engine to propel the bus and power the accessories. Air suspension, eliminating leaf springs, is standard equipment on these coaches



WORLD'S LARGEST extrusion press squeezes out metal shapes up to 110 feet long. Now in operation at Alcoa's Lafayette, Ind., works, the press will be devoted almost exclusively to producing aircraft parts. Other industries, however, will be able to test new designs of structural shapes

ical, $363 ($352); mechanical, $373 ($377); metallurgical, $377 ($317); architecture, $365 ($399).

Engineers Oppose "Gentlemen's Agreements"

Engineers seeking employment are handicapped by employer's "gentlemen's agreements," says the National Society of Professional Engineers. "Gentlemen's agreements" are those under which employers agree not to consider for employment an employee of a firm in the same general field or in the same geographical area until that employee has first severed all connections with his immediate employer.

During its recent annual meeting in Milwaukee, the NSPE went on record opposing these agreements since they "deprive the engineer of the right to seek employment in an effort to better himself without jeopardizing his position." They added that it is for the engineer, rather than the employer, to determine when and how the employer should be notified of an impending shift in employment.

Named officers for the ensuing year were: president—Clarence Shoch of Allentown, Pa., assistant to the commercial vice-president of Pennsylvania Power and Light Co.; and treasurer—R. B. Allen of College Park, Md., professor of civil engineering, University of Maryland.

Vice presidents named were: L. F. Frazza, direct sales manager, Johns-Manville Co., Hawthorne, N. J.; Virgil Gunlock, commissioner of public works, Chicago; M. F. Wooten Jr., a Charlotte (N.C.) consulting engineer; O. C. Mayer,

industrial development director, Idaho Power Co., Boise, Idaho; R. J. Rhinehart, superintendent, Arkansas Power & Light Co., Pine Bluff, Ark.; John B. Jardine, Jardine Bridge Co., Fargo, N. D.

Steel Replacing Brass For Cartridge Case Use

Twelve years of development and manufacturing experience have resulted in the successful use of steel as the primary material for cartridge cases. K. T. Norris, president of the Norris-Thermador Corp. reported in *Ordnance* magazine for May-June 1954 that metal fabricators have successfully deep-drawn steel into cylindrical shapes to the required depths. Using improved manufacturing techniques with proper tool design and exacting thermal treatment, the manufacturers have been able to produce a steel case with properties necessary for proper ballistic performance.

It is desirable that the steel be fine-grained and have nonaging properties, Mr. Norris reports. Since steel mills have not been able to produce "as-rolled" material entirely free from defects, the blanks must be inspected to determine the type and degree of the defect and whether it can be removed by a salvage operation or the blank scrapped. Since some fractures were found to be caused by subsurface defects, a precup-

Convertiplanes — Two-Way Airplanes

Availability of new and better materials has brought forth the possibility of a new "convertible" airplane combining the features of a helicopter and a conventional propeller or jet-powered aircraft.

Equipped with a helicopter-type rotor for vertical lift, these "convertiplanes" are designed to use propellers or jets and wings for forward flight. After rising from the ground by means of its lifting rotor, the plane will convert to high forward speed by one of three proposed methods.

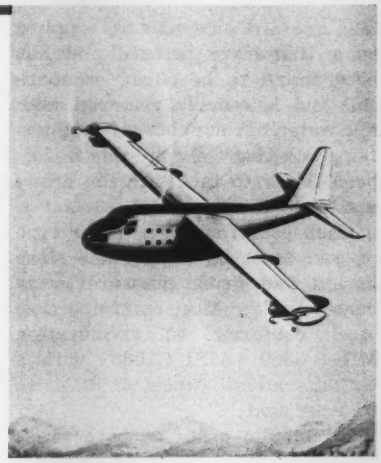
In the first, the rotor continues to rotate in its normal position during all flight conditions. Known as the "unloaded rotor" principle, the rotor thrust is decreased to zero, and rotor speed is decreased to reduce drag.

A tilting rotor system characterizes the second method. Combination rotor-propellers are mounted near the tips of a fixed wing, operating as conventional rotors during vertical and low-speed flight, for high-speed flight, the rotors tilt forward approximately 90 degrees to act as propellers while lift is provided by wings.

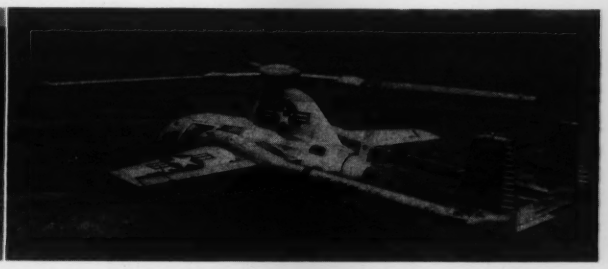
In the retractible rotor type, the third conversion method, the rotor is braked to a stop, then fully or partially retracted to reduce drag.

Two military types are now under development for the Air Force. McDonnell Aircraft Corporation's model XV-1 uses the "unloaded rotor" principle. A tilting-rotor design is being developed by Bell Aircarft Corp. for their model XV-3.

Although the convertiplane is not expected to replace the helicopter entirely its much better speed and range performance, together with improved ability for evasive action, will dictate its use when ever distance and time is critical.



Artist's conception of Bell Aircraft's XV-3 "convertiplane" design using the tilting rotor principle



Two views show the McDonnell Aircraft's XV-1 "convertiplane." Designed to carry three passengers in addition to the pilot, the craft is 30 feet long with a wingspan of 26 feet. Each of the three blades of the rotor is powered by a pressure jet unit located at the tip of the blade. A reciprocating engine on the aft fuselage provides air to the pressure jets as well as power to the propeller

ping operation was introduced. Experience proved that if the blank did not fracture during the precupping operation, it seldom would fracture during subsequent drawing operations.

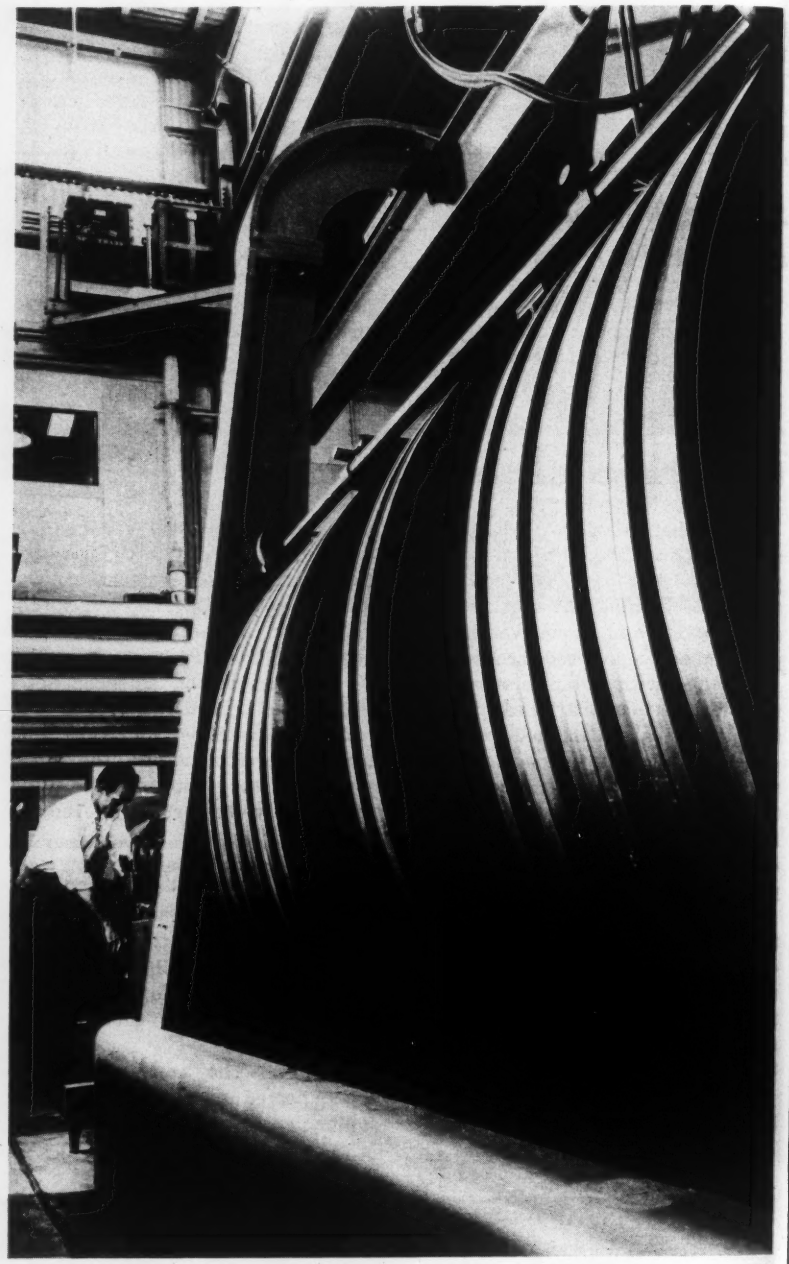
Each drawing operation is designed to cold work the metal within the limits of its mechanical properties. After each draw it is usually necessary to further anneal, pickle, and lubricate the part before further cold-working.

Development of a suitable draw lubricant able to withstand the pressures exerted by the tools was also necessary for successful manufacture. Dried soap applied as a thin layer is used and has been found to be clean, economical, and is quickly removed with hot water. A supplemental underlying coating of phosphate has been found to facilitate the drawing processes.

Each case for a particular type of gun must be tailor-made since design and firing pressures vary considerably. Most cartridge case steel conforms to specification MIL-S-3289 (AISI C1030) with a carbon-content range of 0.25 to 0.35 per cent.

Production costs of both brass and steel cartridge cases are said to be nearly the same. Since the material cost for steel is considerably less than brass, the finished product cost of the steel case is less. Steel cases may be stored for a longer time because steel is not susceptible to season cracking.

New advisory service to companies having screw thread fastening problems has been offered by the Heli-Coil Corp. Called the Thread Engineering Advisory Service, the group is available for consultation on problems pertaining to: (a) tapped thread strengths in brittle metals, light metals, plastics or wood; (b) space limitations caused by tight design specifications; (c) frictional wear on threads subject to frequent disassembly; (d) weight requirements set by high performance goals; (e) vibration wear on threads subject to extreme oscillation; (f) corro-



GIANT DISKS comprise the 27-ton flywheel on this new inertia-type dynamometer. Recently installed at the Johns-Manville Research Center, the dynamometer is capable of producing 100,000 foot-pounds of braking torque and 51 million foot-pounds of kinetic energy. Said to be the world's largest, the machine will be used for testing heavy-duty friction materials in such diversified fields as aircraft, railroads, trucks and busses and industrial applications. Braking conditions, such as the wheel of an airliner landing at 200 mph may be reproduced as well as simulating low-speed, high-torque applications typical of heavy-duty earth-moving machinery

Electronic Brain Designed for Office Work

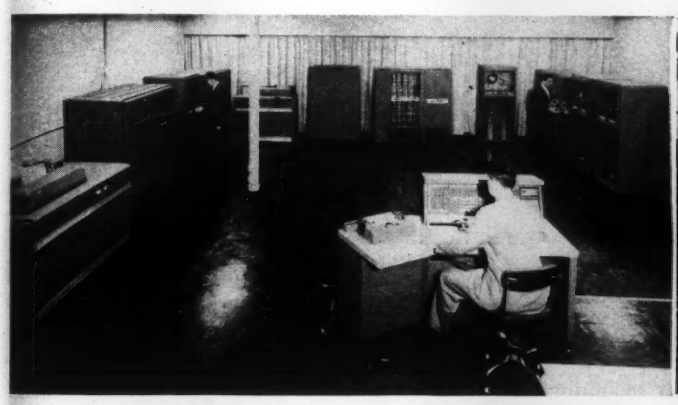
Arithmetic and logic are the specialty of a new data-processing machine capable of performing over a million commercial data-processing operations per hour. Designed and built by IBM, its uses are mainly accounting and statistical work common to large offices.

Similar to the earlier model 701 (MACHINE DESIGN, May, 1953, Page 236), the new model 702 was designed for business use and is said to be the fastest and most flexible commercial data processing system ever devised.

Cathode-ray memory tubes store the program of instructions by which the arithmetical and logical unit of the machine makes decisions. Additional storage capacity is provided by a magnetic drum with magnetic tape units to read and record these data. If desired, IBM cards may be used with the system, and facilities for printing or punching directly from the arithmetical and logical unit are attached. All units are interconnected by cables with overall supervision from an operator's control console.

Supervision over the entire "electronic office" is from this operator's console

It is expected that equipment of this kind will go far in enabling business to take advantage of new management techniques, generally mentioned in terms of "linear programming" and "operations research." These deal with the expression of business situations in terms of mathematics and are said to make possible more efficient and profitable use of production and distribution facilities.



sion resistance of threads subject to high humidity or reactive atmospheres; or (g) thread deterioration caused by high temperatures.

Standards Engineers Increase 300 Per Cent

In about a year, membership in the Standards Engineers Society has increased from 50 to more than 150 members. Organized in 1947 to further standardization, the organization provides means by which standards engineers and others interested in standardization may discuss standardization techniques. The Society does not engage in the creation of standards.

Sections of the Society have been organized in New York, Philadelphia and Binghamton, N. J. Other local sections are in the process of formation. Further information and details of the Society and its purposes may be obtained from Standards Engineers Society, P.O. Box 281, Camden 1, N. J.

General Electric Co. is planning two new plants for increased production of heating devices and controls. A $5 million plant for the manufacture of industrial furnaces, induction heating equipment and heating devices is to be built in Shelbyville, Ind. The other multi-million dollar plant to produce elec-

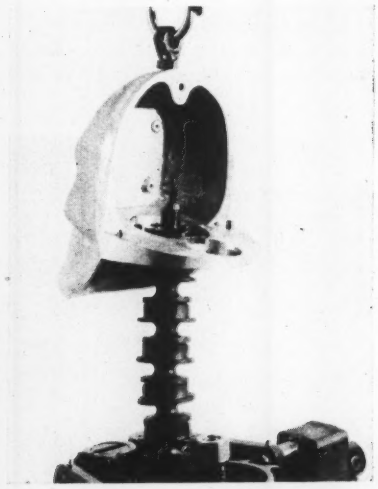
trical controls will be constructed in Roanoke County, Va. Space released by the addition of these new facilities will be used for expansion of other General Electric departments.

Test Dummy Gives Near-Human Responses

Developed to substitute for humans in dangerous tests, a near-human test dummy promises to find wide research applications because of its ability to respond like a man in test situations. Blast-effect studies, aircraft and automotive safety research, ejection-seat tests and the like are all fields in which human subjects would be endangered.

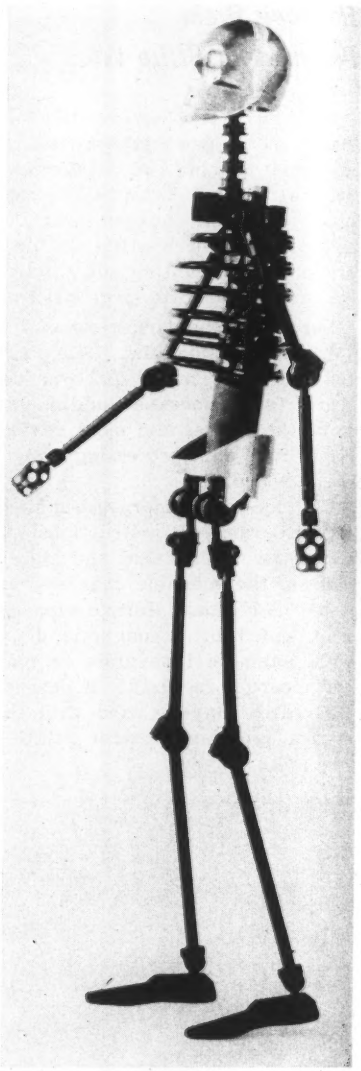
Designed and built by Alderson Research Laboratories, the simulated man carries the name "Mark III Anthropomorphic Test Dummy". It was designed to reproduce human proportions, weight distribution, articulation, resilience and other characteristics which determine the forces imposed upon a man in a given system. The motions he would make under those conditions and his terminal condition are also determined by these characteristics.

Mark III was not designed for destruction or observation of physical damage, but rather to provide means for obtaining physical data. Standard locations for instrumentation are in the head, top of the thorax and at the pelvis. Installations of instruments can include accelerometers, rate gyros, amplifiers, recorders, alternators, switch systems and battery power supplies. In addition to the standard location for the instruments, equipment may also be mounted on brackets at other points.



Instrument mounting bosses are in the front wall of the skull cavity. Instrument moments can be trimmed by suitable weights to preserve a correct overall center of gravity

Data thus obtained are compared with physiological information to give a forecast of probable consequences to human subjects. This method is said to provide more accurate information than can be obtained any other way.



Realism is achieved by simulating the basic plan of construction of the human body. A metal skeleton duplicates a wide range of motions. Molded flesh follows the contour of its human counterpart. Firmness and softness of flesh at any point generally corresponds to a human body in a state of moderate muscular tension. A specially developed vinyl-plastisol foam is used for areas requiring maximum strength while a lighter vinyl-plastisol foam simulates the softer tissues. Skin for the head, neck and torso is cast of the same plastic.

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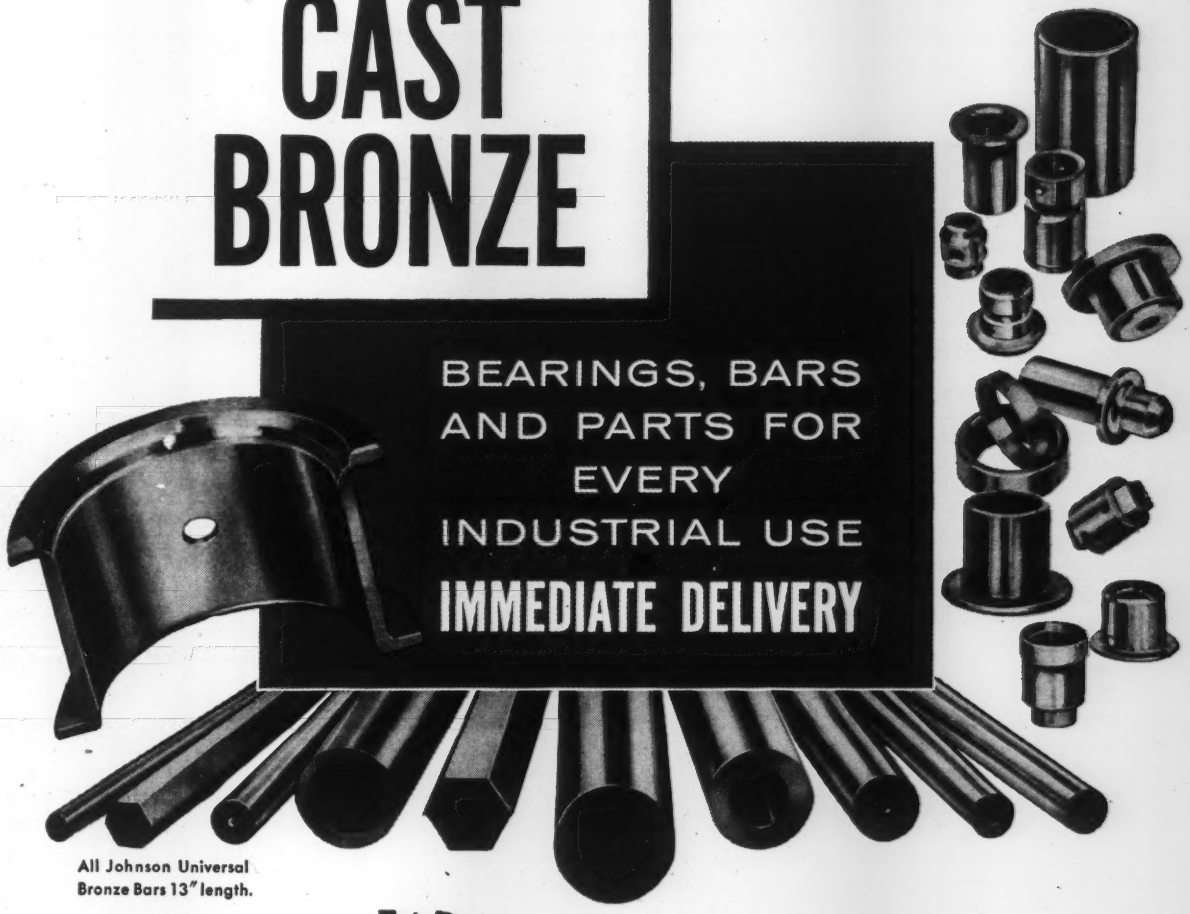

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SLEEVE BEARING HEADQUARTERS SINCE 1901

maintain articulation and body contours. Access to internal cavities facilitates repairs. In the event of damage, a relatively small portion of the unit may be replaced without disassembling the entire body.

A final realistic touch is provided by the catalog packaging specification which reads, "Shipped in a pine box."

LATEST ENGINEERING FACILITIES in this new plant include up-to-date high-frequency vibration, shock, temperature and altitude test equipment. A high-speed movie camera is also on hand to help evaluate performance of a designer's latest effort. To promote engineering efficiency as well as quality production, the new windowless plant of C. P. Clare & Co. is completely air conditioned, sound conditioned, and well illuminated

Unclassified Research On Uranium Encouraged

University research groups are now urged to study uranium and its alloys and the AEC has indicated willingness to provide financial support (as funds are available) to worthy research projects, or to provide necessary small amounts of natural uranium free of charge in return for information developed.

Most research to date has been done at major Atomic Energy Commission laboratories under the usual security conditions. However, there are many fundamental research projects that can be performed on an unclassified basis. For example, studies of mechanisms of corrosion, thermodynamics, phase tranformations, electrochemical studies, and other basic research can be performed as unclassified research.

Work may be carried out under these general principles: First, any subject for research must have the approval of the AEC's Office of Classification, and a license must be obtained for purchase of natural uranium if more than three pounds are to be used. The metal is unclassified, however, and need only be accounted for on the basis of its monetary value. Second, a project leader must generally be given a security clearance so that he may learn what information might be classified and be able to recognize and secure classified information should it unexpectedly be developed. Third, technical reports, although nominally unclassified, must be reviewed by AEC before publication.

Announcing the Second Mechanisms Conference

Planning for this year's Mechanisms Conference, jointly sponsored by Purdue University, *Automation* and MACHINE DESIGN is nearly complete.

Aim of the conference, to be held on October 11-12, 1954 at Purdue University, is to promote better understanding, design and application of mechanisms in machines.

Enthusiastically received by engineers in attendance last year, the 1953 conference served to pinpoint areas of mechanism design and methods or techniques that are of vital concern today. The forthcoming conference will be aimed at correlating available information and filling the gaps in these areas.

Papers to be presented at the four sessions of the two-day conference will deal with *Special Gearing, Mechanism Performance Analysis, Cam Design Problems* and *Lightweight Mechanisms.* Panel group discussions will also be held during the program.

Conference planning committee consists of W. R. Spiller, vice president of engineering, Harris-Seybold Co.; W. A. Witham, executive engineer, Miehle Printing Press and Mfg. Co.; M. S. Curtis, vice president of engineering, Warner and Swasey Co.; W. A. Patzer, president and chief engineer, A.B.T. Mfg. Co.; Roger W. Bolz, editor of *Automation;* Benjamin L. Hummel, associate editor of MACHINE DESIGN; Professors E. S. Ault and A. S. Hall Jr., Purdue University; T. A. McGill, Barkley and Dexter; A. B. Schwarz, chief engineer, Delco Radio Div. of General Motors; C. G. Bigelow, assistant manager, General Engineering Laboratories, American Machine and Foundry Co.; and M. M. McClure, Purdue University.

A complete program appears on Page 339 and an advance registration form will appear in the September MACHINE DESIGN.

ASME Fall Meeting will be held in Milwaukee, September 8 through 10, at the Hotel Schroeder. This is the third national meeting to be held in Milwaukee and will mark

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Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal . . . requiring only 25% more space than lip-type seals.

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the 50th anniversary of the Milwaukee section. Fourteen of the Professional Divisions will hold sessions to report the latest information in their respective fields. A special panel discussion entitled "Developing the Young Engineer" will be held under the auspices of the Machine Design Division. Members of the panel will be George Habach, Worthington Mfg. Co.; Walter Schmitter, Falk Corp.; Joseph Mulheim, Jack and Heintz Inc.; and W. M. Owen, Caterpillar Tractor Co.; with George Nordenholt, editor of *Product Engineering* as moderator.

American Designs To Be Shown in Europe

Fifty examples of American industrial design will be displayed at the 10th Triennale Fair in Milan, one of the important international exhibitions of 1954. Industrial design is the major theme of this year's fair, which will run from August 25th to November 15th.

Assembled by the Society of Industrial Designers, the American exhibit will show Europeans some of the best examples of a wide variety of modern, mass-produced American household and industrial products. It will be viewed by an expected 700,000 European manufacturers and designers as well as visitors from all over the world.

Meetings and Expositions

Sept. 5-8—

Pressed Metal Institute. Annual fall meeting to be held at the Manior Richelieu Hotel, Murray Bay, Quebec. O. B. Werntz, 2860 East 130th St., Cleveland, O., is managing director.

Sept. 7-9—

National Fluid Power Association. Fall meeting to be held at the Hotel Commodore, New York, N. Y. Barrett Rogers, 1618 Orrington Ave., Evanston, Ill., is executive secretary.

Sept. 8-10—

American Society of Mechanical Engineers. Fall meeting to be held at the Schroeder Hotel, Milwaukee, Wis. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 11-14—

Packaging Machinery Manufacturers Institute. Twenty-second annual meeting to be held at Grove Park Inn, Asheville, N. C. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17.

Sept. 13-24—

Instrument Society of America. International instrument congress & exposition to be held at Convention Hall and Commercial Museum, Philadelphia, Pa. P. V. Jones Jr., 1319 Alleghany Ave., Pittsburgh, Pa., is secretary.

Sept. 21-23—

Society for Experimental Stress Analysis. Fall meeting and exhibit to be held at the Hotel Bellevue-Stratford, Philadelphia, Pa. W. M. Murray, P. O. Box 168, Cambridge 39, Massachusetts is secretary.

Sept. 27-28—

Steel Founders' Society of America. Fall meeting to be held at The Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland, O.

Sept. 27-30—

Society of Industrial Packaging & Materials Handling Engineers. Annual exposition to be held at the Coliseum, Chicago, Ill. Additional information may be obtained from society headquarters, 20 West Jackson Blvd., Chicago 4, Ill.

Sept. 28-Oct. 1—

Association of Iron & Steel Engineers. Annual convention and biennial exposition to be held at the Public Auditorium, Cleveland, O. T. J. Ess, 1010 Empire Bldg., Pittsburgh 22, Pa., is managing director.

Oct. 4-6—

National Electronics Conference. Tenth annual conference to be held at the Hotel Sherman, Chicago, Ill. Conference under the sponsorship by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University. University of Illinois, with participation by the Radio Electronics Television Manufacturers Association, Society of Motion Picture & Television Engineers, Purdue University, and University of Wisconsin. R. E. Hornacek, N.E.C., Publicity Committee, 208 West Washington St., Chicago 6, Ill., is chairman.

Oct. 1-2—

Standards Engineers Society. Annual meeting to be held at Haddon Hall, Atlantic City, N. J. F. M. Oberlander, P. O. Box 281, Camden, N. J., is secretary.

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in your product's performance?
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The H-K Selector is definitely not a "gadget". It was designed by design engineers *for* design engineers . . . and it gives the designer every bit of information he must have to select the proper size and type of Socket Screw. It's a complete working tool which we believe you will find very helpful in your work—*and it's free for the asking!*

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HELPFUL LITERATURE
FOR DESIGN EXECUTIVES

1. Hydraulic Pumps

Sprague Engineering & Sales Corp.—Eight models in S-216-C series of air driven high pressure hydraulic pumps are described in 4-page illustrated bulletin. They have discharge pressures from 1100 to 33,500 psi. Operation in various high pressure low volume services is covered.

2. Set Screws

Set Screw & Mfg. Co.—Descriptions, technical data, prices and reference information on conventional and self-locking set screws are found in the 24 illustrated pages of catalog No. 19. Included are fluted socket type for resistance to tampering and slotted offset self-locking type with spring grip lock that resists any backward movement.

3. Expansion Joints

Flexonics Corp.—Basic data necessary for the proper selection and application of pipeline expansion joints are included in 8-page illustrated catalog 133. Types of pipeline motion frequently encountered and methods of handling this motion are discussed.

4. Metal Protective Chemicals

American Chemical Paint Co.—Metal protective and paint bonding chemicals for steel, zinc, aluminum and other metals with industrial applications are subject of 8-page bulletin 1171A. Products for cleaning, paint preparation, corrosion prevention, soldering, stripping copper coatings, paint stripping, pickling and other processes are listed.

5. Hydraulic Cylinders

Benton Harbor Engineering Works, Inc.—Hydraulic cylinders that are custom built for a specific application are described in 4-page illustrated bulletin. Examples of cylinders and their applications are shown. They are available with operating pressures up to 3000 psi, 1½ to 8-in. bore and up to 156 in. stroke.

6. Hoods & Pressurized Plugs

DeJur-Amsco Corp.—Aluminum hoods and pressurized plugs for use with EZ-release series continental connectors are described in 2-page illustrated data sheet. Hoods aid in cable support and strain relief.

7. Clutch-Coupling Units

Formsprag Co.—Dimensional data, service factors and other application engineering data required to specify the correct clutch-coupling are found in 4-page brochure. Models with ratings from 0.4 to 230 hp per 100 rpm are available. Complete specifications are given.

8. Direct Lift Valve

Atkomatic Valve Co.—Specifications for bar stock direct lift valves are found in technical bulletin 100. Valve is rated at 5000 psi at temperatures to 150° F maximum and 2500 psi at temperatures from 150 to 400° F. Valve sizes of ⅛ and ¼-in. are made.

9. Self-Cleaning Coolant Filters

Industrial Filtration Co.—Delpark continuous full-flow self-cleaning coolant filtration units are described and illustrated in 8-page illustrated booklet. Automatic units make use of a disposable belt filter element. Operation data, applications, capacities and specifications are given.

10. Parts Producing Facilities

Orange Roller Bearing Co., Special Parts Dept.—Facilities for producing machined, hardened and ground parts to specifications are outlined in 8 pages of this illustrated booklet. Typical parts are shown. Equipment available for automatic screw machine operations, turret lathe work, internal, external and surface grinding, secondary and finishing operations, heat treating and inspection is covered.

11. Miniature Rigid Controls

Arens Controls, Inc.—Applications and general specifications for miniature rigid push-pull controls are included in 2-page illustrated data sheet. Uses include manual reset operations, direct transmission of motion and power transmission through confined areas. Engineering drawings are presented.

12. Vibration Isolators

Barry Corp.—Engineering data file on Barry controls for isolation of vibration contains an engineering data form and 8-page illustrated bulletin 534 on series M44 All-Metl vibration isolators and series TOMA mounting bases.

13. Aluminum Heat Exchangers

Aluminum Co. of America—24-page illustrated bulletin AD-186 presents complete story on aluminum heat exchanger tubes as used in a wide variety of industries. Cladding to provide corrosion resistance is one of topics covered. Fabrication and design data are presented along with information on fluid flow, heat transfer, mechanical characteristics, cost estimation and other technical material.

14. Industrial Engine

Ford Motor Co.—8-page illustrated catalog describes over-head valve model 134 four-cylinder industrial gasoline engine which produces up to 110 lb ft torque at 80 per cent full load and up to 45½ brake horsepower. Various accessories such as hydraulic pump, power take-off and truck-type transmissions are available. Cut-away and other drawings show design and construction details. Complete specifications are given.

15. Subplate Hydraulic Valves

Rivett Lathe & Grinder, Inc.—Solenoid operated, subplate mounted line of hydraulic valves is subject of illustrated 8-page catalog 260. JIC diagrams show flow operations under all types of action for each of 14 piston designs. Engineering and application data for the 3000 psi shock resistant valve are given.

USE THE POSTAGE FREE CARDS BELOW for copies of anything listed on this or following helpful literature pages—or for further information on any items in the new parts section or the engineering department equipment section which you'll find on the next several pages.

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16. Dynamometer Systems

General Electric Co.—How G-E direct current dynamometer systems can be used for testing internal combustion engines, transmissions, torque converters, pumps, fans, electric motors, compressors and other types of equipment is related in 12-page illustrated bulletin GEA-5923A.

17. Lock Nuts

MacLean-Fogg Lock Nut Co.—Unit-Torque reusable stop-type lock nuts are covered in 8-page illustrated catalog. Regular, jam and high styles are available in 18 standard sizes from ¼ to 2 in. Other sizes are described as available to order. Part of the top threads is deflected from a true helix to produce the locking effect.

18. Replacement Valve Bodies

General Rubber Corp.—Replacement bodies for pinch type valves are described and illustrated in single-page data sheet. Type 1000 flanged and 2000 slip-over pipe type are made in rubber, neoprene, butyl, buna S, buna N and other materials for working pressures to 125 psi.

19. Investment Casting

Hitchiner Mfg. Co.—"Investment for Economy, for Performance" is a 12-page brochure which outlines the investment casting process, illustrates the diverse types of parts which can be made, presents design considerations and offers cost and production facility data.

20. Modifying Phenolic Resins

Hercules Powder Co.—Revised 32-page technical booklet covers use of Vinsol resin to reduce cost of phenol-formaldehyde resins. Vinsol is a phenolic compound which can be used as modifier or extender. Booklet includes sections on aldehyde condensates, solvent-blended phenolic resins, water-blended phenolic resins and phenol-formaldehyde copolymers. Liberal use is made of charts and graphs.

21. Pneumatic Line Equipment

M-B Products—Line of automatic air line filters, air pressure regulating valves, automatic air line lubricators and pneumatic grinders is described and illustrated in this loose-leaf catalog, a collection of over 12 data sheets. Engineering drawings and prices are given, along with air capacity charts.

22. Screw Conveyors

Continental Gin Co., Industrial Div.—Screw conveyor engineering data book ID-541 is designed to aid in selection of a conveyor for any application. Various types and sizes of conveyors are described and illustrated, and tables and other data aid in determination of type, size and drive horsepower required.

23. Vibration Elimination

International Research & Development Corp. —Entitled "Balance—Final Dimension of Precision", 16-page illustrated brochure discusses relationship between vibration phenomena and precision manufacturing. Portable vibration analysis equipment is also covered.

24. Magnesium Castings

Magline Inc.—Facilities for production of magnesium sand castings, fabrications and their design and engineering are described in 8-page illustrated brochure. Examples of parts produced are shown.

25. Magnetic Coolant Separator

Barnes Drill Co.—12-page illustrated catalog covers automatic permanent magnet type separators for cleaning used coolant from metalworking machines. Construction and design data are furnished on various models which have capacities ranging from 1½ to more than 360 gpm coolant.

26. Precision Fasteners

Chandler Products Corp.—"Chandler Precision Cap Screws" is title of 4-page illustrated catalog showing various standard and special fasteners. They are cold forged from high carbon, alloy or stainless steels in diameters from ¼ to ⅞-in. and in lengths up to 5 in. standard. They are available with special heads, shanks or threads.

27. Flow Control Valves

A-P Controls Corp.—Capsule data and illustrations show a broad line of flow control valves in 4-page catalog "Solve These Flow Control Problems." Concise data are furnished on capacity ranges, connection and orifice sizes, lift and other specifications of valves for gas, oil, refrigerant and other media.

28. Lubricated Plug Valves

Homestead Valve Mfg. Co.—Full-port and venturi-type lubricated plug valves in sizes up to 14 in. are covered in 24-page illustrated catalog 39-5. Choice of two or one-piece plug designs is available. Dimensions, types of control, materials and lubricants are discussed.

29. Hydraulic Presses

Denison Engineering Co.—"Ideas on How You Can Cut Costs and Boost Production with Denison Multipress" is an informative 4-page brochure (No. 153). Blanking and forming, riveting, coining, drawing, crimping and swaging operations are shown.

30. O-Ring Data Book

Plastic & Rubber Products Co.—Design and engineering data on O-ring seals are contained in engineering handbook No. 504. Charts, illustrations and graphs are used to back up text. Materials, grooving, gland finishes and lubrication are among subjects covered.

31. Hydraulic Cylinders

Hydro-Line Mfg. Co.—8-page bulletin 53 gives complete description of series J hydraulic cylinders for 2000 psi oil hydraulic service. Design data are given. Fixed and rotatable foot, front and rear flange and clevis and trunnion mounting styles are available. Bore sizes range from 1 to 8 in.

32. Universal Joints

Gear Grinding Machine Co., Joint Div.—12-page illustrated catalog describes applications, engineering data, design, specifications and other material relative to Rzeppa Constant Velocity universal joints. Advantages are shown and selection information is given.

33. Pneumatic Equipment

Gardner-Denver Co.—Illustrated bulletin GF-100 covers pumps, compressors, rock drills and other industrial pneumatic equipment. Condensed specifications are grouped according to product type for easy reference. Portable air compressors are available with capacities ranging from 60 to 600 cfm.

34. Mercury Plunger Relays

Ebert Electronics Corp.—UL-approved mercury plunger relays are subject of 4-page illustrated catalog 154. Current loads up to 6 amp and motor loads up to 3 hp can be handled by units, which are fast-acting, hermetically sealed and explosionproof. Ratings and other specifications are given in full.

35. Polyester Resins

Bakelite Co.—20-page booklet L-10 contains up-to-date information on polyester resins and their use in the manufacture of reinforced plastic structures. Information is given on compounding, reinforcing materials, mold release agents and other aspects of production. Both casting and molding techniques are included, together with wet and dry machining.

(Continued on Page 194)

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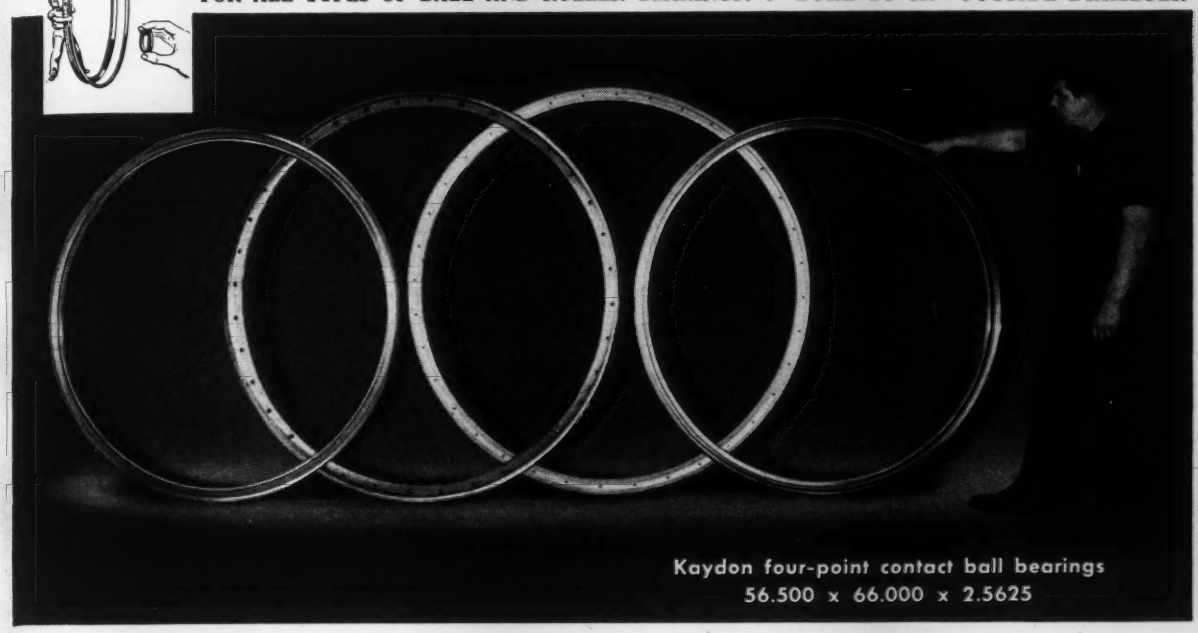

Kaydon four-point contact ball bearings
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Featherweights for heavy-duty applications — built by Kaydon

To keep a classified product's overall design within practical limits, a major manufacturer required special bearings. Specifications included: extremely thin section in relation to 66" O.D. . . . light weight . . . with integral gear teeth and strength to withstand constant, hard usage. Furthermore, the bearings would have to be mass-produced.

Knowing that **KAYDON** concentrates in design and production of special thin-section and/or high-precision bearings, the manufacturer got in touch with **KAYDON** sales engineers. In a short time the heavy-duty feather-weights, shown here, were developed to solve the problem.

Similarly, for special bearings you, too, can save time, money and trouble by contacting **KAYDON** of Muskegon.

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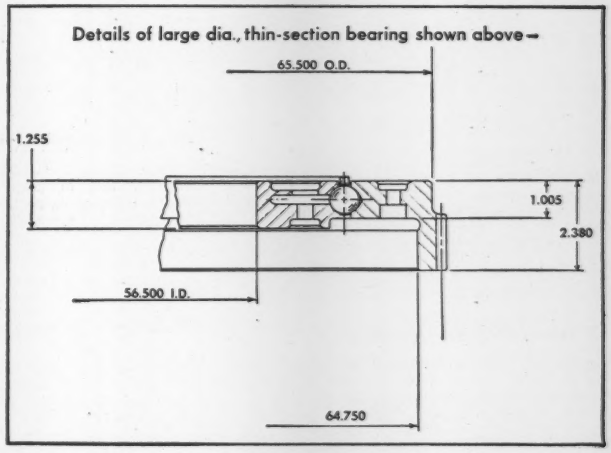

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PRECISION BALL AND ROLLER BEARINGS

Helpful Literature

(*Continued from Page 192*)

36. Bevel Gear Units

Airborne Accessories Corp. — Standardized right angle Coniflex bevel gear drive units in 1/3 and 1 hp sizes are featured in 4-page illustrated catalog ANG-54. Units are furnished with 1:1 ratio and either two or three shaft extensions. Rated speed is 1800 rpm. The 1-hp unit is of 1000 in.-lb static torque capacity.

37. Shell Molding

General Electric Co. — 28-page brochure CDC-272 describes latest developments in shell molding and provides information on resins and new foundry techniques in this field. Case histories, testing methods and production techniques are comprehensively treated in the publication.

38. Electronic Components

Servomechanisms, Inc.—12-page illustrated general products brochure covers such electronic components as mach computers, master air data computers, accelerometers, potentiometers and positioning mechanisms. Design facilities and service are also described.

39. Trims & Escutcheons

American Name Plate & Mfg. Co.—Use of decorated metal stampings as functional component parts is illustrated in 4-page brochure "Trims, Panels & Escutcheons." Examples cover wide range of end product uses that vary from locomotives to table model radios. Piece size variation is from less than 1 sq in. to 37 x 8-in. stove panel.

40. Rubber Grommets

Goshen Rubber Co.—Listed and illustrated in 12-page bulletin are many sizes and types of grommets which can be produced to order. Line includes AN931 series of 34 basic sizes, each size available with $\frac{1}{16}$, $\frac{1}{8}$, $\frac{3}{16}$, and $\frac{1}{4}$-in. groove widths, plus 34 sizes in web type with $\frac{1}{8}$-in. groove. Grommets can be rubber, synthetic rubber or silicone.

41. Magnetostriction

International Nickel Co.—Eleven graphs and extensive selected bibliography are highlights of 28-page bulletin A-169 entitled "Magnetostriction." Report discusses ferromagnetic metals and alloys, giving data on some of their magnetostrictive properties. Numerous devices employing this phenomenon are described and explained.

42. Laboratory Glassware Washer

Heinicke Instruments—Comparative advantages of Heinicke laboratory glassware washers are pointed up in 4-page folder. Washers feature powerful above and below jet streams that readily penetrate even capillary pipettes. Pressure is such as to reflect at flask bottom in all directions for scrubbing action over entire inside and outside of glassware.

43. Glass-Silicone Insulation

Formica Co.—Glass-silicone laminate used for electrical insulation is covered in 4-page illustrated catalog. Special attention is given to use in sealed dry-type transformers. Product is available in form of spacer bars or barrier sheets. It is specially useful for applications where operating temperatures are high.

44. Roller Bearings

McGill Mfg. Co.—Besides pictures and descriptions of Sealed Guiderol bearing construction, function and uses, 4-page bulletin SGR-54 contains tabulated dimensions, load capacities, life and speed factors and shaft and housing fits and tolerances. New bearing adds single or double seals to standard roller bearings without increasing overall size.

45. Transformers, Reactors

United Transformer Co.—28-page catalog A presents complete line of transformers for broadcast, amateur, laboratory and replacement purposes. Illustrations show a few of thousands of special transformers, reactors, filters and magnetic amplifiers for military equipment. These are manufactured in hermetic and Fosterized designs to MIL-T-27, AN-E-19, etc.

46. Stainless Alloys

Cooper Alloy Foundry Co.—Available technical booklet consists of 11 reference sheets covering major stainless alloys. Chemical composition, mechanical and physical properties, resistance to major corrosives, machinability, heat treatment and weldability comprise data given on each alloy.

47. Self-Priming Pumps

Duriron Co.—Model 40 series R corrosion-resistant, self-priming Durcopumps are described as to construction, performance, priming operation and features. After priming, air handling capacity is up to 54 cfm with 10-ft static lift.

48. Precision Washers

Detroit Stamping Co.—Two pages of 4-page illustrated catalog comprise list of sizes in which precision washers are available from stock. Range covered is from $\frac{3}{32}$ to 8 in. ID. Back page of catalog briefs such products as valves, arbor spacers, shim and feeler stock and toggle clamps.

49. Velocity Stage Turbines

De Laval Steam Turbine Co.—Described in 4-page illustrated bulletin 4202 are velocity stage class CA turbines for mechanical drives which operate under all inlet steam conditions up to 600 psig and 750° F. Maximum speed of turbine available in two frame sizes is 4000 rpm with shaft governor, up to 6000 rpm with vertical or hydraulic governors. Specs are covered.

50. Contract Screw Machining

Avalon Machine Products, Inc.—Facilities for precision automatic screw machine work are covered in 12-page illustrated bulletin. Typical products are illustrated. Policy of company regarding quality control, hourly rates, purchase of new equipment and employee relations is described.

51. Glass Cloth Finish

Libbey-Owens-Ford Glass Co.—The Garan finish applied to glass cloth used in reinforcing plastics imparts high flexural, compressive and tensile strength to the plastic, according to 8-page form FTY-5 describing this finish. Two-page chart of properties of Garan-finished fiber-glass fabric-polyester laminates is featured.

52. Silicon Transistors

Texas Instruments Inc.—Specifications, plus mechanical and electrical data on both 900 and 901 general purpose silicon transistors and the X-15 medium power silicon transistor are provided in two bulletins. Transistors will operate up to 150° C, with current amplification factor being independent of temperature change. The X-15 is rated at 1 w power dissipation.

53. Welding Design Manual

Eutectic Welding Alloys Corp.—In 14 pages of "Manual of Design and Welding Engineering" are detailed instruction on joint design with drawings showing difference between good and bad. It shows types of joints possible, their names and when they should be used. Sections are devoted to overlaying and hard-surfacing as well as inspection and control.

54. Circular Drawing Machine

Charles Bruning Co.—Precise ellipses, spirals, helixes and arcs are drawn mechanically in matter of seconds by circular drawing machine described in available literature. Samples of drawings made by machine and time it took to draw them are shown. Supplementary 4-page folder describes use of technical illustration templates.

55. Teflon Packings

Durametallic Corp. — Dura Plastic Teflon packings made in styles to resist acids, ammonia, light hydrocarbons and solvents are briefly described in form 461. Temperature range of packings is —90 to 450° F.

56. Quick-Sealing Couplings

Titeflex, Inc. — Quick-Seal hose couplings available in an unlimited range of sizes to handle any material that will flow through a line are illustrated with tabulated thread sizes in 16-page brochure. Straight through, check valve and block-ell couplings and assemblies are covered.

57. Centrifugal Pumps

Ingersoll-Rand Co. — "Centrifugal Pump Fundamentals" is 12-page booklet which explains principles of operation, defines terms used in pump calculations and works out typical pump problems. Pump analogies, calculation, total head or pressure, capacity, specific gravity, hydraulic and brake horsepower and pump pressures are topics considered.

58. Magnesium Fabrication

Brooks & Perkins Inc.—Company's magnesium fabrication facilities and services are described in 8-page booklet. Highlight is chart showing relative strength and stiffness in bending of structural metals.

59. Multiple V-Drives

Raybestos-Manhattan, Inc. — Features of Poly-V drives are pointed up in 8-page folder 6638 which opens up into large wall chart. Belt is one-piece type with multiple V-shape corrugations which grip matching sheave. Synthetic cord strength member spans entire belt width.

60. Quality Bronze

Saginaw Bearing Co.—Sabeco bronze, suited for all types of engine parts, motors, turret lathes, locomotive bearings and bushings, oil seals and other type parts is described in 4-page folder. Five grades are listed with their recommended uses.

61. Properties of Ceramics

American Lava Corp.—Mechanical and electrical properties of AlSiMag ceramics are tabulated in chart No. 544. Vitreous ceramic materials, lava and refractories are covered. Thermal expansion and dielectric strength charts are included.

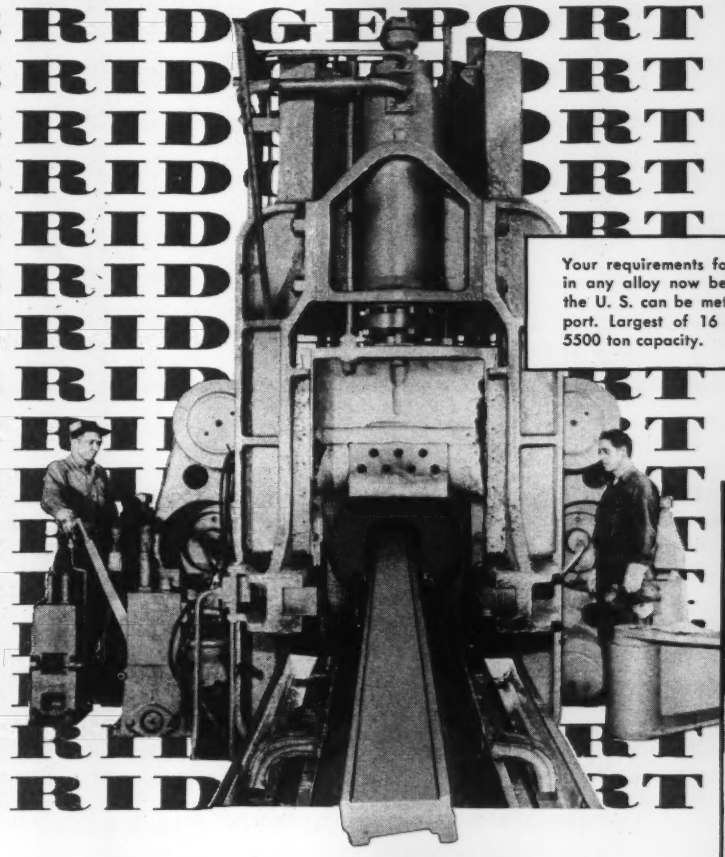
62. Circuit Breaker Engineering

Heinemann Electric Co.—Bulletin No. 201 is a 24-page illustrated guide on application of circuit breakers to protective and control functions. Detailed data are given on principle, design and operation of hydraulic-magnetic breakers. Technical material includes time delay curves and impedance charts.

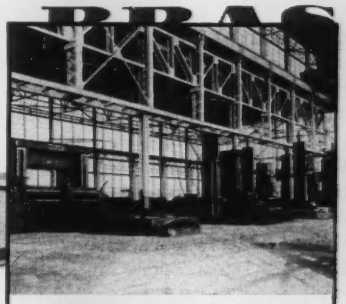
63. Hydraulic Components

Hydraulic Press Mfg. Co., Hydraulic Power Div.—28-page condensed catalog 1101 illustrates and describes line of air and oil hydraulic components. Design, operation and capacities of the various items are considered. Pumps, motors, power units, cylinders, valves and hydraulic circuit cylinders are included.

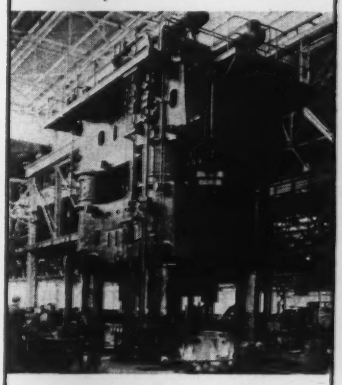
BRIDGEPORT BRASS



Your requirements for extrusions in any alloy now being used in the U. S. can be met by Bridgeport. Largest of 16 presses has 5500 ton capacity.



Fast deliveries are possible because both extrusion and forging dies are designed and produced in our own completely equipped die shops.



With facilities such as this huge, 16,500 ton forging press, one of the largest in the country, Bridgeport can meet the most exacting demands for quality die forgings. Aluminum and magnesium contour hand forgings are also produced.

A background of experience and skill that assures you quality in Bridgeport Aluminum

The experience and skill in metal production that mean greater efficiency and lower manufacturing costs to users of Bridgeport brass mill products, are now available to users of aluminum extrusions and forgings.

Bridgeport has a 90 year reputation for quality and service and over four decades of experience in extruding metals. From this background we offer skilled technical assistance and assurance of meeting your most exacting specifications in aluminum.

For a continuing, dependable source of quality aluminum products call on Bridgeport. We have the modern production facilities, the quality-control equipment, the skilled technicians and a determination to give superior service.

Contact your nearest Bridgeport district office for information about Bridgeport extrusions and forgings in terms of your products. We are prepared to give you immediate service and deliver quality materials on the schedules promised.

Bridgeport

BRIDGEPORT BRASS COMPANY
ALUMINUM DIVISION • Bridgeport 2, Conn.
Sales Offices in Principal Cities—Conveniently Located Warehouses
Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich.

See our exhibit at the National Aircraft Show September 4-5&6...Dayton, Ohio

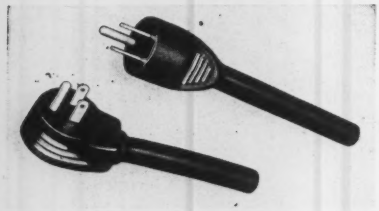
BRIDGEPORT ALUMINUM

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 191

Three-Conductor Plugs

Blades and grounding pins in line of molded rubber three-conductor male attachment plugs are positioned according to National Electrical Code regulations effective in January 1955. Straight and right-angle plugs feature parallel blades for 15-amp, 125-v operation and tandem blades for 15 amp, 250-v operation. All are Underwriters' approved and available for wire gage sizes from 12-3S to 16-3SJ.

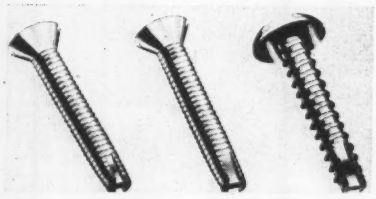


Ground wire is secured to a contacting pin projecting from the plug end parallel to the blades. Made by Cords Ltd. Div., **Essex Wire Corp.**, DeKalb, Ill.

For more data circle MD-64, Page 191

Self-Tapping Screws

Tapping screws with two balanced cutting edges require low driving torque. Wide flutes provide chip room; close thread fit from the two flutes resists backward rotation and vibration. Standard screws are heat-treated alloy steel. Type G2 is designed for steels, alloy steels and cast iron. Type G3 is for die-casting use in soft metals. Type H3 is for use in plastics, and has coarse threads

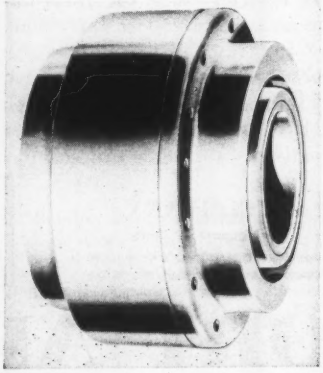


to give high stripping torque. Made by **Continental Screw Co.**, New Bedford, Mass.

For more data circle MD-65, Page 191

Large-Bore Clutches

Series of clutches having up to 12-in. bore incorporates the sprag principle. Used for over-running, indexing, and backstopping, the clutches provide maximum torque capacity for size and weight and instantaneous engagement without

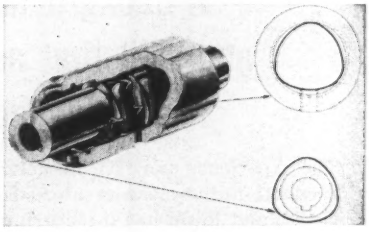


head shaft wind-up. Ball bearings are used in construction. Made by **Formsprag Co.**, 23601 Hoover Rd., Van Dyke, Mich.

For more data circle MD-66, Page 191

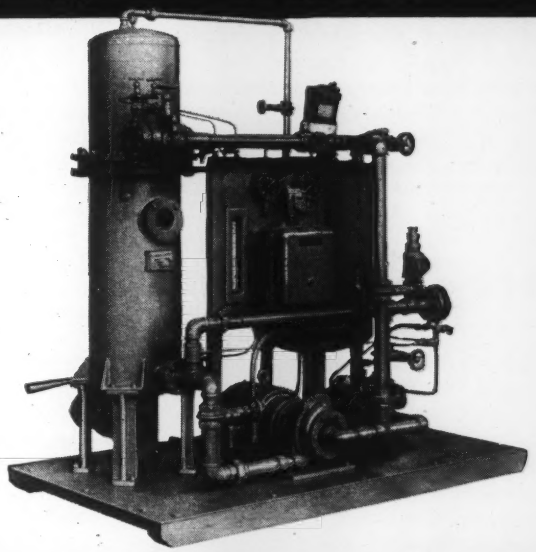
Universal Coupling

Available in standard sizes to 5 in. in diameter, this coupling has driving members of equilateral trilobe shape. This shape is composed of a combination of radii



and is void of tangent flats. An arcuate profile on the periphery of male members provides angular rotational displacement. Coupling has 8 deg angular rotational displacement. Driving members are self-centering under all loads. Engagement between male and female members is held to maximum 0.0002-in. side clearance; bearing contact is 85 per cent of total driving area displacement; and working surfaces are finish ground to maximum 10 mu in. rms. Coupling has high load carrying capacity as well as high axial and torsional strength in relation to its weight. Operation is smooth and quiet un-

HOW TO FILTER WATER FOR OIL RECOVERY



Crane Wedge Disc Clamp Gate Valve . . . extra strong, extremely compact. Clamp design is ideal where easy cleanout may be required. Bonnet assembly and disc lift out —body stays in the line. O.S. & Y., inside screw, and quick-opening patterns, all-iron or brass trimmed. Screwed or Flanged ends. Sizes up to 4 in. Working pressures up to 150 psi saturated steam, 225 psi cold service.

another successful product design with piping equipment by CRANE

Water flooding for oil takes a lot of specialized water treating equipment. A prominent supplier is R. P. Adams Co., Buffalo, N. Y., whose field test filter unit for secondary recovery is shown here.

The Adams design provides permanent filter mediums and permits easy backwashing without disassembly. Built for rugged service, the unit is equipped with Crane piping materials for added dependability.

Dependability is the big reason, of course, why more and more design engineers specify from the familiar Crane Catalog. But they also know that here is a reliable source of valuable piping information. For each piping item, Crane provides the data you want . . . sizes and dimensions, temperature and pressure ratings, plus a run-down on materials and construction. Fully indexed, of course, to save you time.

YOU'LL FIND IT HERE ...IN YOUR CRANE CATALOG

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

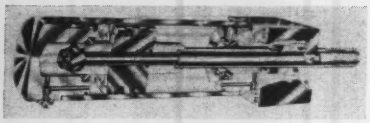
VALVES • FITTINGS • PIPE • PLUMBING • HEATING

der heavy loads. Made by **Kerns Mfg. Corp.**, Dept. 106, 45-18 Court Sq., Long Island City 1, N. Y.

For more data circle MD-67, Page 191

Air, Hydraulic Cylinders

Spacemaker cylinders, now available for use with either air or oil, are extremely compact, since they have no tie rods. Cylinders are made with solid steel heads, heavy wall seamless steel body and chrome plated cylinder walls and piston rods. Fast-acting cushions

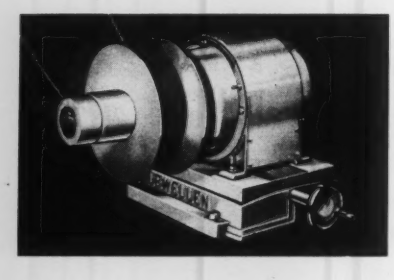


are used. Maximum operating pressures are 200 psi for air and 750 psi for oil. Cylinders are available in six standard styles of mounting, bores from 1 through 4 in. and strokes from 1 through 12 in. in 1-in. increments. Cushioned or noncushioned 14, 16 and 18-in. models can be had also. Made by **Tomkins-Johnson Co.**, Jackson, Mich.

For more data circle MD-68, Page 191

Variable-Speed Pulley

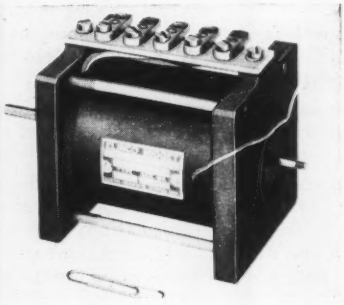
Ratings from fractional to 15 hp are available in redesigned line of variable speed pulleys, each size scaled to all present and new NEMA motor frames. Overhung load has been reduced 50 per cent and space requirement, 40 per cent. Speed ranges of 2¼ to 1, 3 to 1 and 4 to 1 are offered, along with companion bases, countershafts and variable pulley belts for obtaining wide range of machine speeds and center distances. Mounting can be on either a horizontal or vertical motor shaft, driving a flat or crown face pulley or a sheave at the machine shaft. Made by **Lewellen Mfg. Co.**, Tenth St. and Michigan Ave., Columbus, Ind.



For more data circle MD-69, Page 191

Induction Servo Motor

Type DPJJD-764-38 two-phase induction servo motor with double-ended shaft has a low-inertia squirrel cage rotor which eliminates cogging at low speeds. Precision-built unit provides a high torque-to-inertia ratio, low starting voltage, and linear torque-speed characteristics with maximum torque at stall. It can be wound with two or four poles. During 60-cycle operation, output is 5 w, stalled torque is 5 oz-in., and control phase stalled impedance is 5000 ohms. The unit can be made to operate from a single

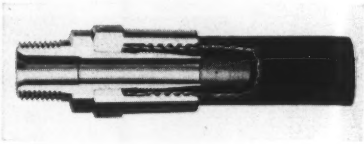


phase source by splitting the phase with a capacitor. It is also available for 400 cps operation, or designed to specifications. Made by **Electric Indicator Co.**, Camp Ave., Springfield, Conn.

For more data circle MD-70, Page 191

Hose Coupling

Two-piece reusable hydraulic hose coupling, for single-wire braid, cotton-covered hose, is in-

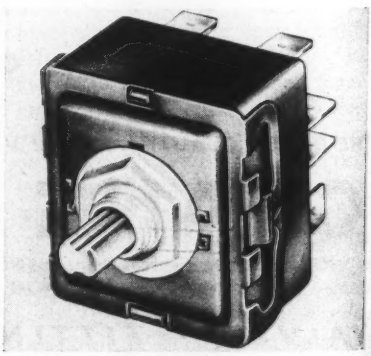


stalled without special tools. Inter-Lock gripping action draws hose into recess in coupling body and into undercut in coupling insert, providing a double grip on the hose. Couplings are plated steel and are available in thread sizes of ⅛ through 1 in. NPTF male, 7/16-20 through 15/16-12 JIC 37-deg swivel female and 7/16-20 through 1 1/16-14 SAE 45-deg swivel female. They are used on 3/16 through ⅞-in. ID hose at pressures ranging from 3000 to 800 psi. Made by **Eastman Mfg. Co.**, Manitowoc, Wis.

For more data circle MD-71, Page 191

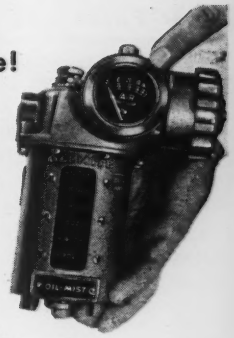
Small Rotary Switches

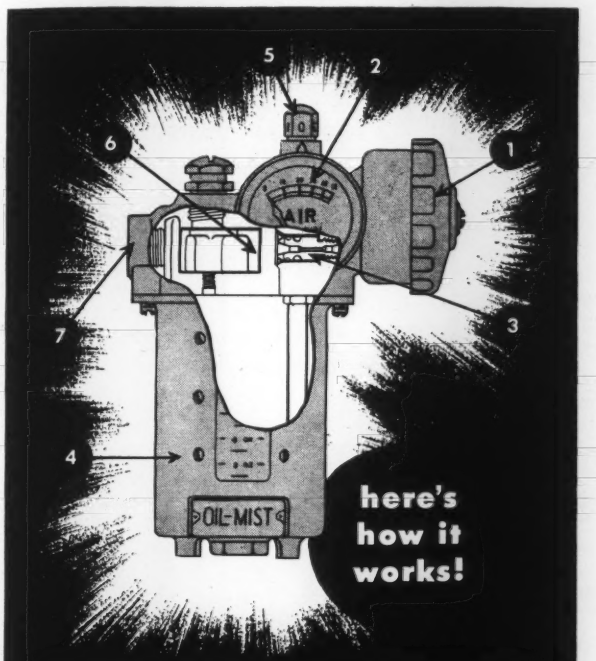
Spindle of the Diamond H series 390 switch may be extended through the back of the base to permit operation of dampers or gears and the ganging of electrical controls. Interchangeable spindle shapes and dimensions are available. Switch, which has very high current carrying capacity, also incorporates spade terminals to permit use of quick connectors. Switch bases may be equipped with dummy terminals, either a pair of terminals with two spades each or a single terminal with four spades, to eliminate terminal blocks. Single-pole or double-pole contacts are available, with 2 to 12 positions and with stop as re-



Designers told us what they needed—what industry had to have!

ALEMITE OIL-MIST





This Oil-Mist Lubricator atomizes oil into microscopic particles which are carried in the air stream and distributed through tubing to the bearings. Compressed air enters and passes through the air regulator (1) and air gauge (2) As this air passes through venturi (3) it draws oil from the reservoir (4). Oil flow is set by knob (5). The mixture of oil and air from the venturi is thrust against the baffle (6). Only the most minute, lighter-than-air particles are blown through the outlet (7) into the delivery line to bearings.

Proved in countless applications . . . MULTIPLIES Bearing Life . . . SLASHES Product Spoilage—BOOSTS Machine Output!

Case history after case history tells the record-breaking story of Alemite Oil-Mist efficiency. This amazing lubrication system has actually multiplied bearing life up to twenty times! Has eliminated product spoilage and housekeeping problems encountered with other lubricating methods! Has increased production on machine after machine! Yet the cost of Oil-Mist is surprisingly low—far less than the cost of even one major bearing failure!

This completely new concept in lubrication is extremely simple. Easy to incorporate into new designs—equally easy to use in modifying existing designs. Oil-Mist applies a constant, clean, cool film of oil uniformly to working parts—groups of bearings, slides, chains, gears—wherever needed. And in the form needed—liquid, spray or mist. Replaces grease systems. Lubricator has no moving parts—operates on compressed air, is completely automatic, completely foolproof!

A complete range of models and multiple unit models, in capacities of 12 ounces and one gallon, assure you a perfect choice for any application!

THREE TYPES OF BEARING FITTINGS

allow the use of Oil-Mist on any machine!

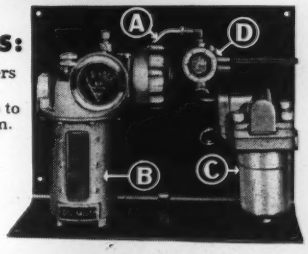
Oil-Mist Fittings bring the most efficient lubrication in the world to any anti-friction bearing—roller, needle or ball.

Spray Fittings are recommended for open and enclosed gears and chains. Allow for a concentrated spray of oil where it is needed.

Condensing Fittings apply oil in liquid form to plain bearings, slides, ways, vees, cams and rollers.

LUBRICATOR SPECIFICATIONS:

- Oil-Mist outlet ½" fem. p.t. Air gauge registers to 50 psi. Operating air pressure—5 to 20 psi.
- Air regulator (A) reduces from pressures up to 200 psi. Normal air consumption—.7 to 1.2 cfm.
- Range of oils handled—to 1,000 sec. (S.U.V.) @ 100°F.
- Oil reservoir (B) capacity 12 oz. (approximately 1 week supply). Intake filter screen—70 mesh. Fill plug—9/16".
- Material—die cast aluminum body with nylon plastic window.
- Baffle-type water separator (C)—automatic self-dumping. Requires no manual attention—no filter elements to replace. Air inlet ¼" fem. p.t.
- Solenoid Control (D) starts system automatically when machine starts—foolproof.



Alemite Oil-Mist offers these lubrication advantages

Automatic Lubrication • Continuous Lubrication

Eliminates Guesswork • Greater Safety • Cuts Oil Consumption up to 90% • Extension of Bearing Life • Stops Oil Drippage

Reduction of Bearing Temperatures • Manpower Savings

Elimination of "Down-Time" • Reduction in Number of Lubricants • Protection from Contamination

Alemite OIL-MIST Lubrication

A PRODUCT OF SW STEWART WARNER

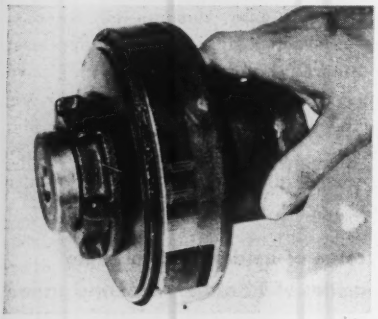
Write Today! This Oil-Mist Catalog and Engineering Data Book is FREE for the asking. Write now for your copy. Alemite, Dept. R-84, 1850 Diversey Parkway, Chicago 14, Illinois.

quired. Underwriters' approved rating is up to 25 amp at 120 or 240 v and ½, ¾ and 1 hp at 120 and 2 hp at 240 v ac. Switches are also available with low dc ratings. Body of switch is 1½ x 1¼ x ⅞-in. Made by **Hart Mfg. Co.**, 110 Bartholomew Ave., Hartford, Conn.

For more data circle MD-72, Page 191

Torque Limiter Coupling

Wide variety of machinery drives with direct-connected shafts can be given overload protection by this adjustable torque limiter-coupling. Compact unit can be adapted to motor drives with torque loads up to 260 lb-ft which include a direct-

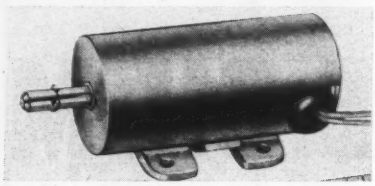


coupled motor or motor and speed reducer combination. When machine drive overload conditions cause the torque setting to be exceeded, the torque limiter slips at from one-third to one-half the torque setting. Drive is rendered inoperative until motor is shut off and overload condition corrected. Coupling is 6 in. OD and 5½ in. long with maximum torque capacities of 130-lb-ft and 260 lb-ft. Standard bore sizes are 1, 1⅛, 1¼, 1⅜ and 1½ in. Made by **Morse Chain Co.**, 7601 Central Ave., Detroit 10, Mich.

For more data circle MD-73, Page 191

Miniature DC Solenoids

Model 20287 has an open coil with a bracket, and model 20288 has a coil enclosed in a steel shell.



Both may be wound for a wide range of dc voltages. Units measure 1½-in. long by ¾-in. diameter. Nylon bobbin is used as bearing surface, providing self-lubrication and insulation, and armatures are high grade soft iron. Leads are on side for convenience in mounting. The 24-v, 13-amp type operated on intermittent duty, 5 seconds maximum on time with 20 C ambient, will pull 25 oz at ¾-in. stroke. Applications include operation of keyboards, light springs, control board signal flags, and door latches. Made by **Cannon Electric Co.**, 418 West Ave. 33, Los Angeles 31, Calif.

For more data circle MD-74, Page 191

Two-Cycle Engines

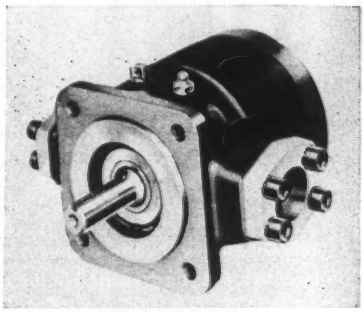
Lightweight, compact engines are available in range from 1 to 3½ hp, in both horizontal and vertical shaft models. Two-cycle principle of operation permits the use of a small piston and eliminates the need for oil reservoir, oil pump, camshaft, gears and valves. Lubricating oil is mixed directly with the gasoline. Model AH-80, illustrated, is a 3½-hp, one-cylinder air cooled engine with 2¼-in. bore and 1½-in. stroke. Shaft

is vertical and rotates counterclockwise. Heavy-duty ball bearings are located at both ends of forged steel crankshaft. Piston is aluminum alloy, and cylinder is die-cast aluminum alloy with cast-in, honed cast iron sleeve. Engine weighs 26 lb. Made by **Power Products Corp.**, Grafton, Wis.

For more data circle MD-75, Page 191

Hydraulic Pumps

PF-100 series dual vane hydraulic pumps operate in pressure range of 1000 to 3000 psi. All moving pumping parts are contained in a replaceable cartridge. Disassembling the pump or changing a pumping cartridge can be accomplished in minimum time with-

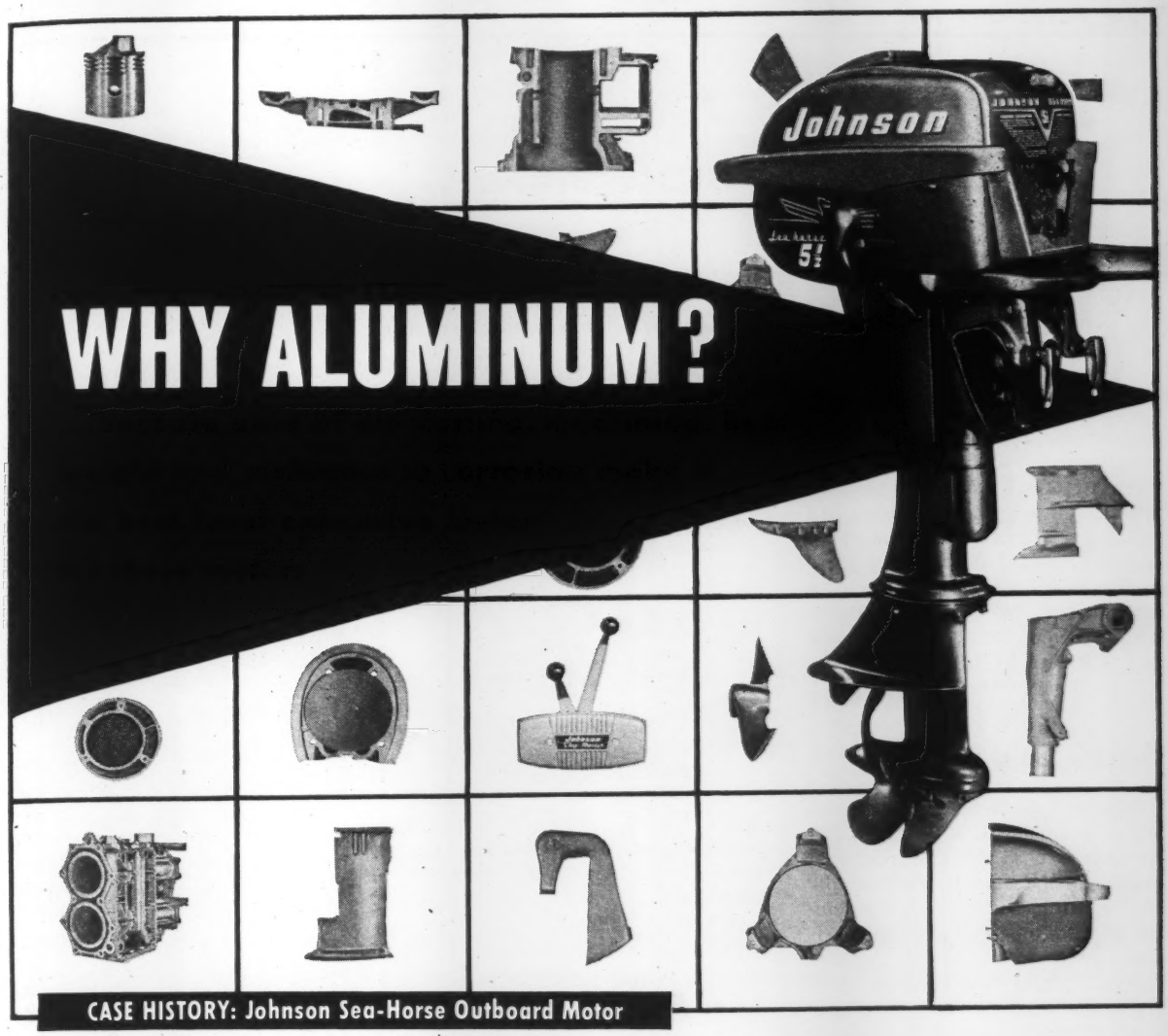


out special tools. Two-vane pump construction provides multiple fluid seals, which minimize slippage, and permits greater loads within pressure range. Full balance of pressure loads ensures long pump life. Pressure-held port plate has controlled movement to allow for expansion of parts caused by hot oil in cold pump or by heat generated if pump is accidentally operated dry. Made by Dudco Div., **New York Air Brake Co.**, 1700 E. Nine Mile Rd., Hazel Park, Mich.

For more data circle MD-76, Page 191

Mechanical Shaft Seal

Sleeve mounting and outside clamping ring of type 9 mechanical shaft seal permit quick installation or removal on most split-case pumps. Seal can be fitted without



WHY ALUMINUM?

CASE HISTORY: Johnson Sea-Horse Outboard Motor

Advances in Aluminum Die-Casting have opened the door to increased production, lower costs for Johnson. Johnson pioneered the use of aluminum and reduced the weight of outboard motors by 65% with the initial aluminum motor.

Because the outboard motor *must* remain portable, aluminum's resistance to corrosion and the light-but-strong quality prove ideal, give more power-per-pound than any other metal. There are more than fifty-five different aluminum die-castings in the motor shown here.

Aluminum die-castings permit close dimensional control that results in minimum machining. Thin, strong wall sections and intricate contours are made possible. Excellent surface finishes are achieved without grinding or buffing.

You, too, can take advantage of aluminum advantages and also get Reynolds engineering and styling help in the design of your products. Remember—aluminum is light but strong . . . is always attractive (frequently without special finishes) . . . has excellent heat and light reflectivity . . . high electrical and thermal conductivity.

Consult Reynolds Aluminum Specialists on your next design or redesign project. Call the Reynolds Office or Distributor listed under "Aluminum" in your classified directory or write Reynolds Metals Company, 2521 So. Third St., Louisville 1, Kentucky.

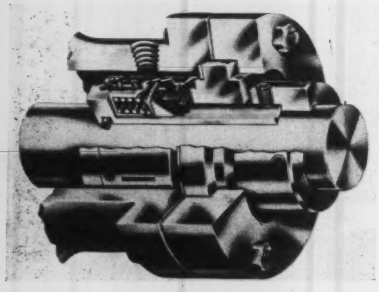
Designed in REYNOLDS ALUMINUM

Look for this new seal in color on foil identifying products "Designed in Reynolds Aluminum"

See "Mister Peepers", starring Wally Cox, Sunday nights on NBC-TV

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

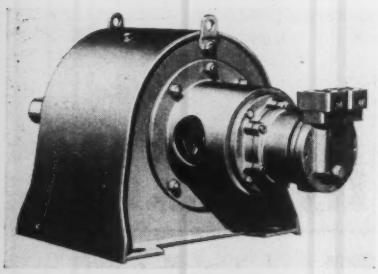


unbolting the top of the horizontal split shell. Seal is unaffected by most corrosive liquids at temperatures to 500 F. Flexible sealing members are Teflon. Springs and metal parts can be furnished to required metallurgical specifications. Sizes are also available to specification. Made by **Crane Packing Co.**, Dept. MDC, 1800 Cuyler Ave., Chicago 13, Ill.

For more data circle MD-77, Page 191

Variable Speed Drives

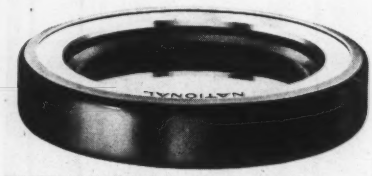
Oilgear type H fluid power axial piston motors in 1, 3, 8, 12 and 20-hp sizes are flange and resilient-coupling connected to Falk single, double, triple and quadruple reducers to form integral, compact variable speed drives called Oilgearducers. Ratio combinations provide output speeds from 1.7 to 1170 rpm. Continuous-operation output torques, based on 1100-psi pressure, range from 42 to 41,500 lb-in. Starting and peak torques for intermittent service can be 60 per cent higher. Similar concentric units with oil-tight shaft seals for vertical wall mounting and with round face flanges for floor mounting are also available for vertical shaft applications. Oilgearducers with single or double right angle output shafts are also available in ratios from 5:1 to 1500:1. Made by **Oilgear Co.**, 1598B W. Pierce St., Milwaukee 4, Wis.



For more data circle MD-78, Page 191

Coated Oil Seals

National metal-encased oil seals are now available with an outer coating which serves as a sealer. Sealing is permanent, and the Redicoat sealing material fills scratches or imperfections 0.003-in. deep and is unaffected by −60 to 350 F temperatures. Seals are removable even after prolonged exposure at high temperature. Made

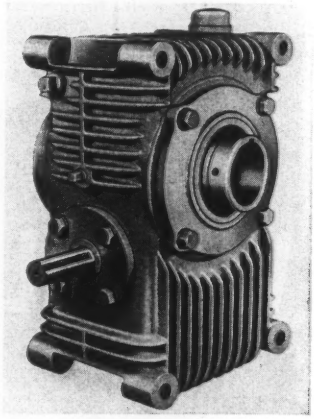


by **National Motor Bearing Co. Inc.**, P. O. Box 1030, Redwood City, Calif.

For more data circle MD-79, Page 191

Speed Reducers

Employing double - enveloping worm gearing, these shaft-mounted, right-angle speed reducers are available with 2, 2½ and 3-in. center distances and can be furnished in pinion under, pinion over or vertical shaft models. Load capacities range from fractional to 3, 5½ and 9 hp, respectively, for the three sizes. Reduction ratios for the two smaller models are from 5:1 to 50:1; for the 3-in. reducer, ratios range from 5:1 to 60:1. Bore sizes for the 2-in. unit range from 1 through 1⅜ in.; for the 2½-in. model, from 1 through 2 in.; for the 3-in. model, from 1 3/16 through 2½ in., all in 1/16-in. increments. All bores in 2-in. models are machined to size without bushings. Bushings are used in 1 through 1⅜-in. sizes of 2½-in. units and in 1 3/16 through 1⅞-



in. sizes of 3-in. unit. Made by Cone-Drive Gears Div., **Michigan Tool Co.**, 7171 E. McNichols Rd., Detroit 12, Mich.

For more data circle MD-80, Page 191

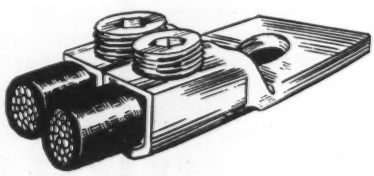
Styrene Plastic

General purpose SMD-3500 styrene plastic, developed for use on all types of injection molding machines, produces parts that are relatively free from strains and weld lines. It fills out corners evenly and produces distortion-free parts. Available in crystal and colors, material has high degree of clarity and maintains purity and uniformity of colors. Made by Bakelite Co., Div. of **Union Carbide and Carbon Corp.**, 260 Madison Ave., New York 16, N. Y.

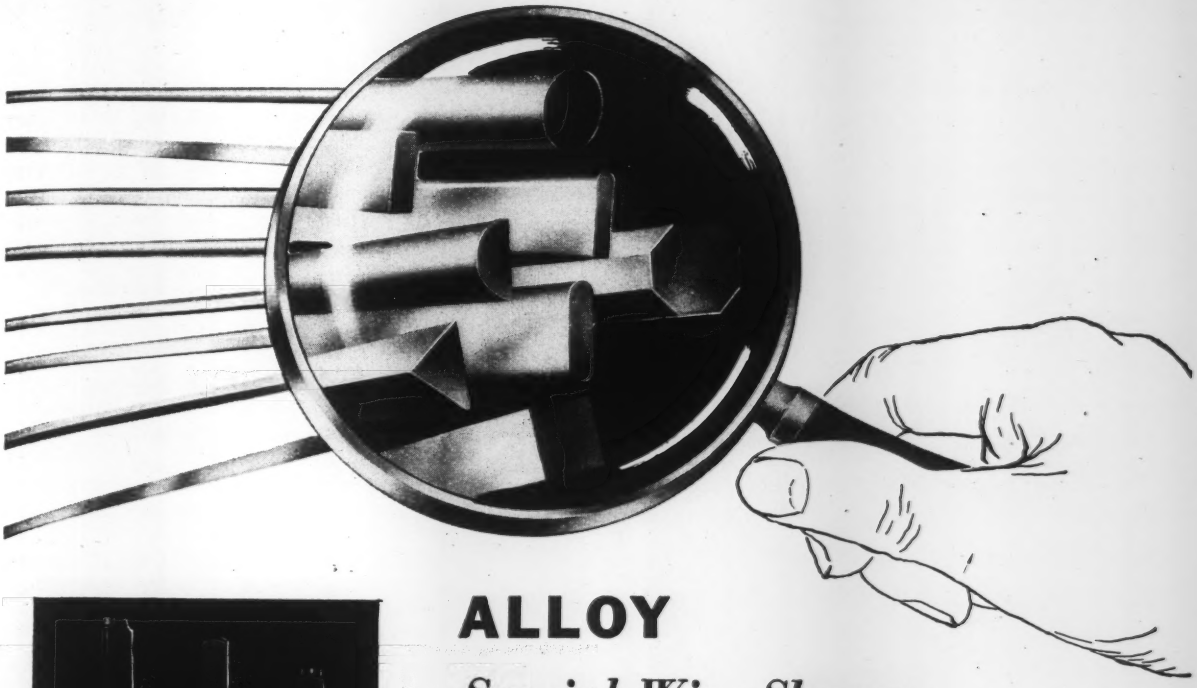
For more data circle MD-81, Page 191

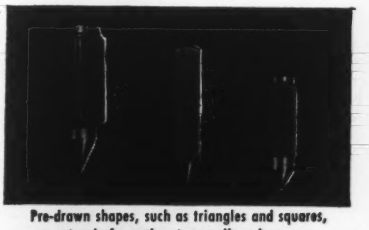
Twin Connector

Compact MU twin connector is as wide as two of the largest conductors which it can accommodate.

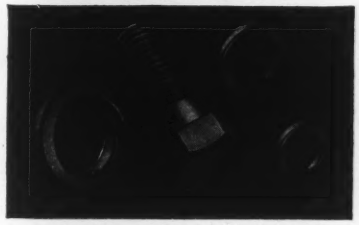


It is available in three sizes: MU 250 for 250,000 cir mils-6 wire range, MU 350 for 350-4 wire

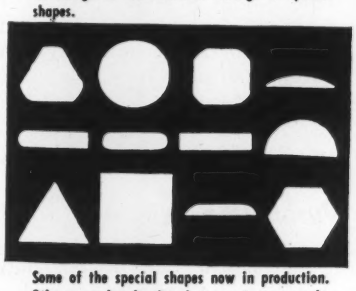




Pre-drawn shapes, such as triangles and squares, are naturals for carburetor needle valves.



Hex-head bolts and flat-wire lock washers take advantage of the material savings of special shapes.



Some of the special shapes now in production. Others can be developed to meet your needs.

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Drawn Alloy Wire Shapes provide other advantages in addition to reduced costs. Product quality and performance are also improved. The drawn wire insures uniformity of cross-section and a smooth, flaw-free surface.

For more details on Alloy Special Wire Shapes or for information on Stainless, Nickel Alloy or Electrical Resistance Wire, Rod and Strip, drop us a line. We are happy to be of service to you.

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1

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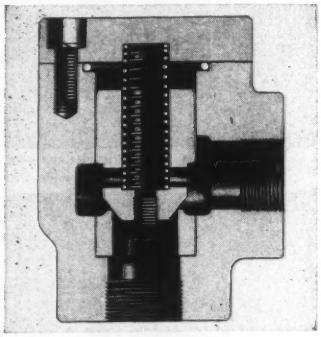
New Parts

range and MU 600 for 600,000 cir mils to 4/0 wire range. Connector is made from heavy, extra hard drawn seamless copper tubing of 100 per cent electrical conductivity, ensuring low heat rise. Made by **Ilsco Copper Tube and Products Inc.**, Mariemont Ave., Cincinnati 27, O.

For more data circle MD-83, Page 191

Hydraulic Check Valves

For service up to 3000 psi, line of hydraulic check valves has high capacity. Valves are available in ¼ to 1½-in. sizes, the latter having 104.2 gpm capacity at 15 ft per second. Valves are available with pipe thread or flange connections



and can be mounted in any position. Model 8640 is spring closed; model 8642 is pilot operated and model 8644 is pilot operated with pressure breaker. Made by **Rivett Lathe & Grinder Inc.**, Brighton 35, Boston, Mass.

For more data circle MD-83, Page 191

Pushbutton Switches

Redesigned line of pushbutton switches has improved shock resistance, longer life, easier assembly and operation. Improvements have been achieved by using fewer, stronger plungers; latch bars with added springing; easier operating contact lifters; and extruded and punched channel sections. The new model MPB switch consists of extruded frame on which are mounted pushbutton units of from 2 to

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Hydraulic power

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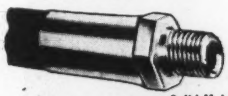
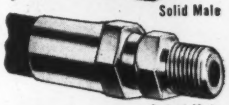


Solid Male



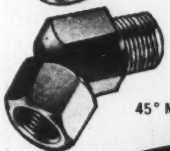
Swivel Male

Swivel Female

STRAIGHT AND ANGLED ADAPTER UNIONS

Straight Male

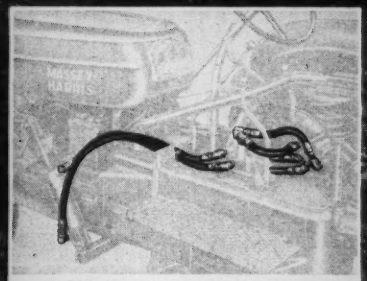
90° Male



45° Male

Write

for free catalog 103 on Eastman Hose Couplings and Bulletins 231B & 232B on Straight and Angled Adapter Unions.



EASTMAN Hydraulic Hose Assemblies on Massey-Harris Tractor.

Thanks to hydraulic power, many a man's job on the farm is a boy's job now! Fingertip hydraulic control does away with aching arms, dog-tired from day-long tugging at levers to raise and lower tillage tools.

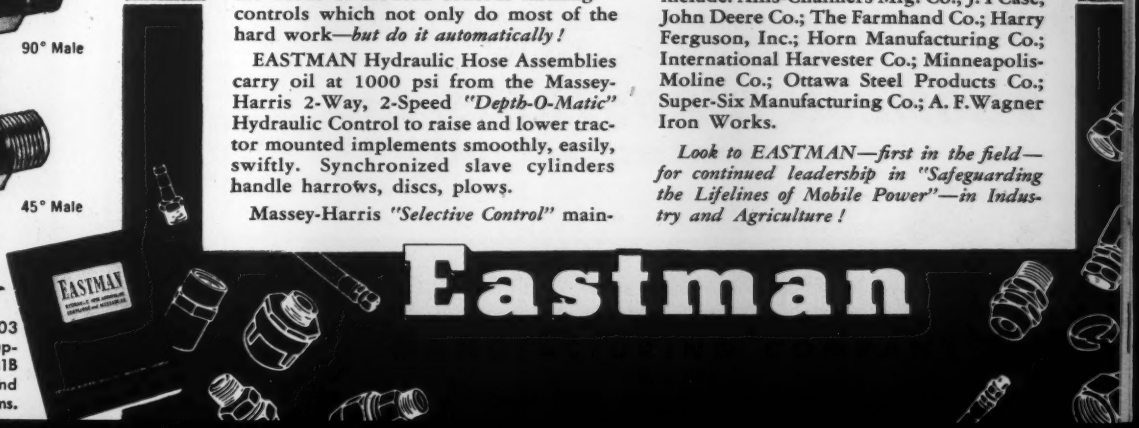
Massey-Harris, shipping agricultural tractors and implements to 106 countries the world over, has developed some of the most ingenious hydraulic controls to meet the needs of modern contour farming—controls which not only do most of the hard work—*but do it automatically!*

EASTMAN Hydraulic Hose Assemblies carry oil at 1000 psi from the Massey-Harris 2-Way, 2-Speed *"Depth-O-Matic"* Hydraulic Control to raise and lower tractor mounted implements smoothly, easily, swiftly. Synchronized slave cylinders handle harrows, discs, plows.

Massey-Harris *"Selective Control"* maintains uniform cultivator penetration on hillside contour slopes, pictured above, through independent action of right and left gangs. *"Delayed Action"* permits raising front and rear gangs independently at contour points, also permits shovels to leave and enter soil at same point at ends of rows.

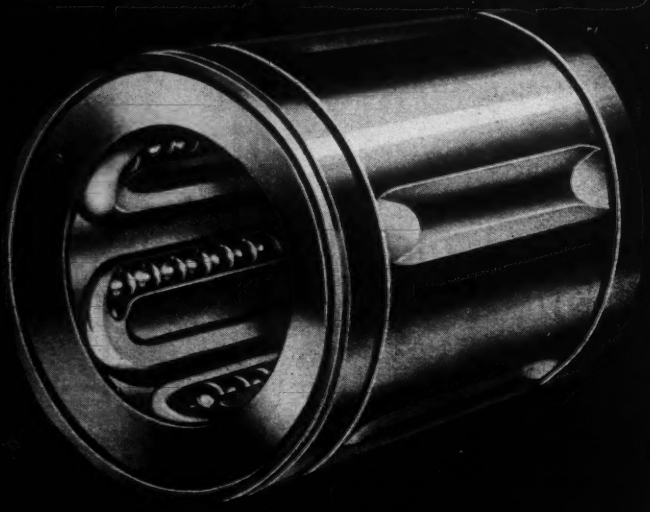
Other users of EASTMAN Hydraulic Hose Assemblies in the agricultural field include: Allis-Chalmers Mfg. Co.; J. I Case; John Deere Co.; The Farmhand Co.; Harry Ferguson, Inc.; Horn Manufacturing Co.; International Harvester Co.; Minneapolis-Moline Co.; Ottawa Steel Products Co.; Super-Six Manufacturing Co.; A. F. Wagner Iron Works.

Look to EASTMAN—first in the field—for continued leadership in "Safeguarding the Lifelines of Mobile Power"—in Industry and Agriculture!



Eastman

BALL BUSHING



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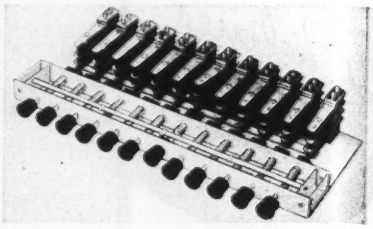
Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

New Parts

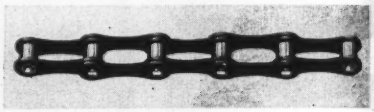


12 positions. Units can be supplied in accumulative lock, no two interlock, lock release and nonlock types. Made by **General Control Co.**, 1200 Soldiers' Field Rd., Boston 34, Mass.

For more data circle MD-84, Page 191

Roller Chains

Line of double pitch roller chains which operate over roller chain sprockets, is now available for light conveying, materials handling

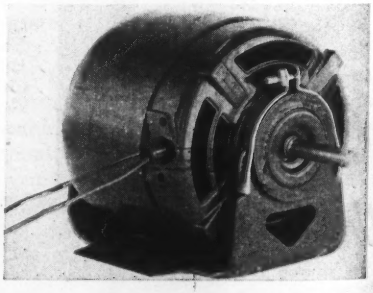


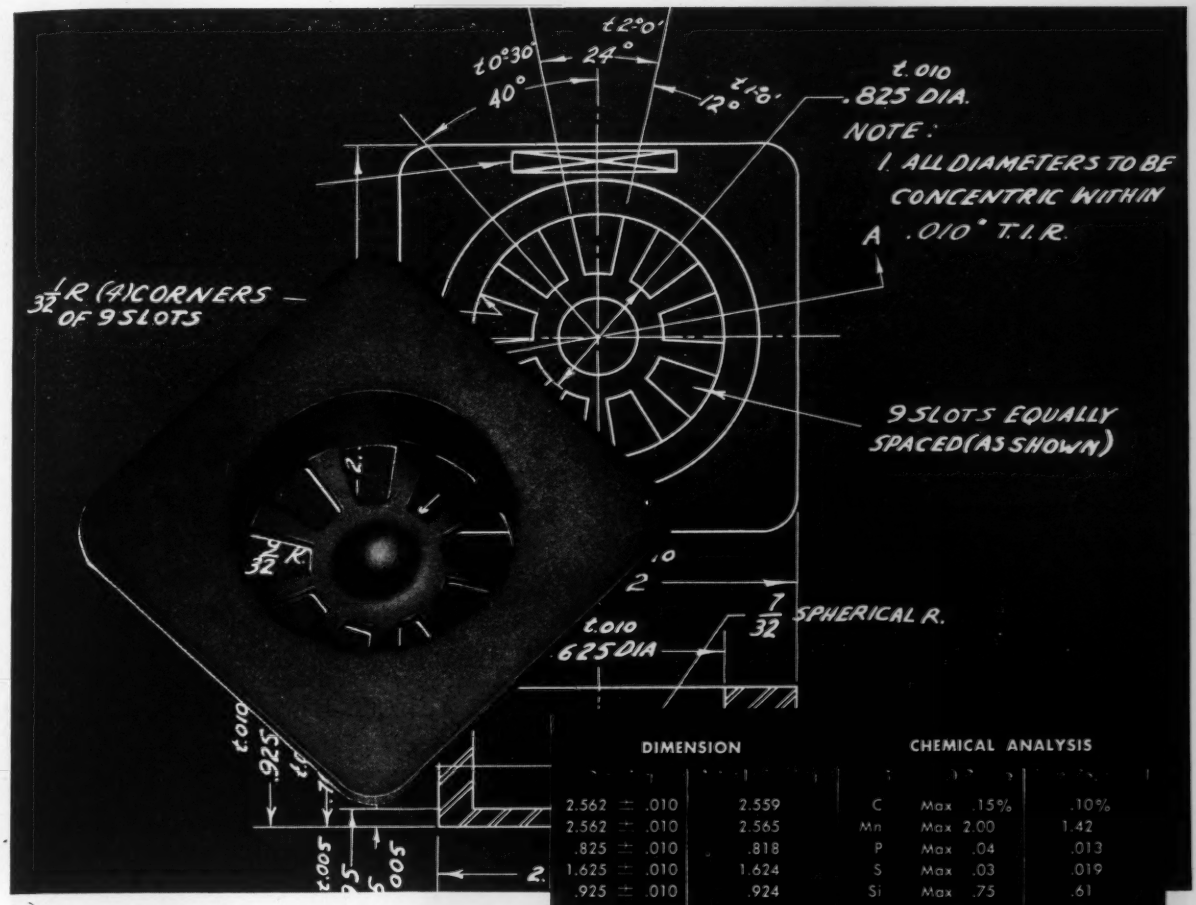
and moderate speed power transmission. They are American Standard stock chains, and stock attachments are available for the conveyor line. Made by **Diamond Chain Co.**, 402 Kentucky Ave., Indianapolis 7, Ind.

For more data circle MD-85, Page 191

Shaded-Pole Motors

Redesigned KSP 21-frame fractional-horsepower motor is suited for application to mechanical drives with moderate radial and axial





DIMENSION			CHEMICAL ANALYSIS		
2.562 ± .010		2.559	C	Max .15%	.10%
2.562 ± .010		2.565	Mn	Max 2.00	1.42
.825 ± .010		.818	P	Max .04	.013
1.625 ± .010		1.624	S	Max .03	.019
.925 ± .010		.924	Si	Max .75	.61
.700 ± .010		.698	Ni	12.00-14.00	13.00
.105 ± .005		.109	Cr	16.00-18.00	17.70
2.050 ± .010		2.058	Cu	Max .50	.07
.295 ± .005		.293	Mo	1.50-2.25	1.96

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the efficiency of your hydraulic unit with Roper dependable Pumps. Get optimum performance from the pumps that feature just two moving parts — equal size gears operating in a sturdy case with proper clearance for superior service and long life. The models shown are representative of standard Roper pumps suitable for most applications.

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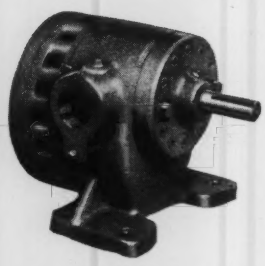
Rotary Pumps
FOR YOUR
HYDRAULIC
APPLICATIONS

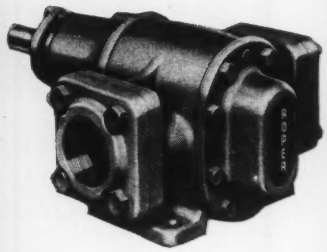


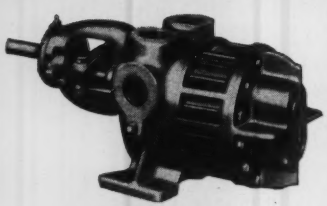
LOWER

maintenance costs with a Roper. For instance, a pump like the Series H with pressures to 1000 P.S.I., sizes 10 to 75 G.P.M. is ideally suited for hydraulic mechanisms and for other applications requiring high pressures. Spur gears run in axial hydraulic balance . . . bearings and bronze wear plates reduce friction under heavy loads. Available with packed box or mechanical seal.

PUSH

the unit in your hydraulic circuit with the correct size Roper for the particular job. In many cases the Series K will do, for it is rated from pressures to 150 P.S.I., capacities ¾ to 50 G.P.M. This model is compact, sturdy . . . is self-lubricated by liquid pumped . . . handles total suction lifts up to 25 feet. Comes with packed box or mechanical seal . . . with or without relief valve.





ROPER
Rotary Pumps

GEO. D. ROPER CORPORATION
248 Blackhawk Park Ave., Rockford, Illinois

PULL

favorable comment on a wise choice when you install a Roper as original equipment. Among the dependable Ropers is the Series F Pump —pressures to 300 P.S.I., sizes ¾ to 300 G.P.M. It features four-port design with 8 optional piping arrangements . . . supplied in standard or stainless steel fitted models. With packed box or mechanical seal; with or without relief valve.

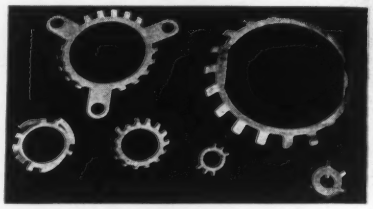
New Parts

thrust where quiet performance is required. New ½-in. shaft provides increased rigidity to long single and double-shaft drives. Mounting versatility has been increased by 20-in. leads and a 3½-in. shaft-height base. A 2⅝-in. shaft-height base is also available. End-mounted or resilient-base, open and totally-enclosed fan-cooled models are available in 1550-rpm, 4-pole, 60-cycle ratings of 0.015 to 1/10-hp, and in 1050-rpm, 6-pole, 60-cycle ratings of 0.025 to 1/10-hp. Made by Specialty Component Motor Dept., **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-86, Page 191

Die-Cut Lock Washers

Custom made lock washers for shaft sizes from ⅛ to 6 in. are available in small lots without the expense of conventional blanking and piercing dies. Washers may



be sheet metal stock, including cold rolled steel, spring bronze, spring steel or any other sheet alloys. Made by **Dayton Rogers Mfg. Co.**, 2830 S. 13th St., Minneapolis 7, Minn.

For more data circle MD-87, Page 191

Switch-Starter

Compact die-cast housing encloses a selector switch and fractional horsepower manual starter. The "Auto - Off - Hand" selector switch permits remote control from a thermostat, or local control from the starter; the manual starter provides motor overload protection. Two manual starters, without the selector switch, are also available in the same enclosure. Maximum ratings are 1 hp at 115 or 230 v single phase ac, or

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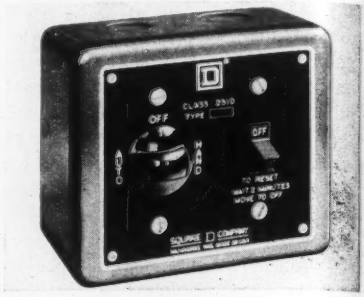
New Parts

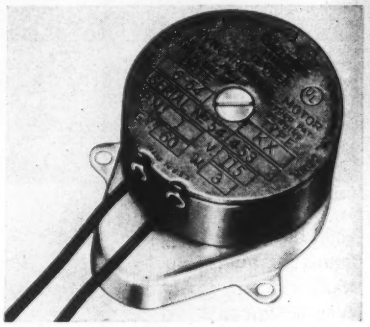


115 or 230 v dc. Made by **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

For more data circle MD-88, Page 191

Synchronous Motor

Type KX motor delivers 30 oz-in. of torque at 1 rpm. It permits neither slip nor sub-synchronous speed and operates in any position. Permanently lubricated, motor is available with a wide variety of output shafts and in a speed range



from 1 rpd to 60 rpm, for right, left, or oscillating rotation. It starts instantly and stops within two cycles. At rated load, temperature rise is 43 C. Made by **R. W. Cramer Co. Inc.**, Centerbrook, Conn.

For more data circle MD-89, Page 191

Packless Valves

Standard models of bellows type packless valves are rated for service up to 150 psi from −65 to 250 F, and with minor modifications can be adapted for much greater extremes. Both hand and

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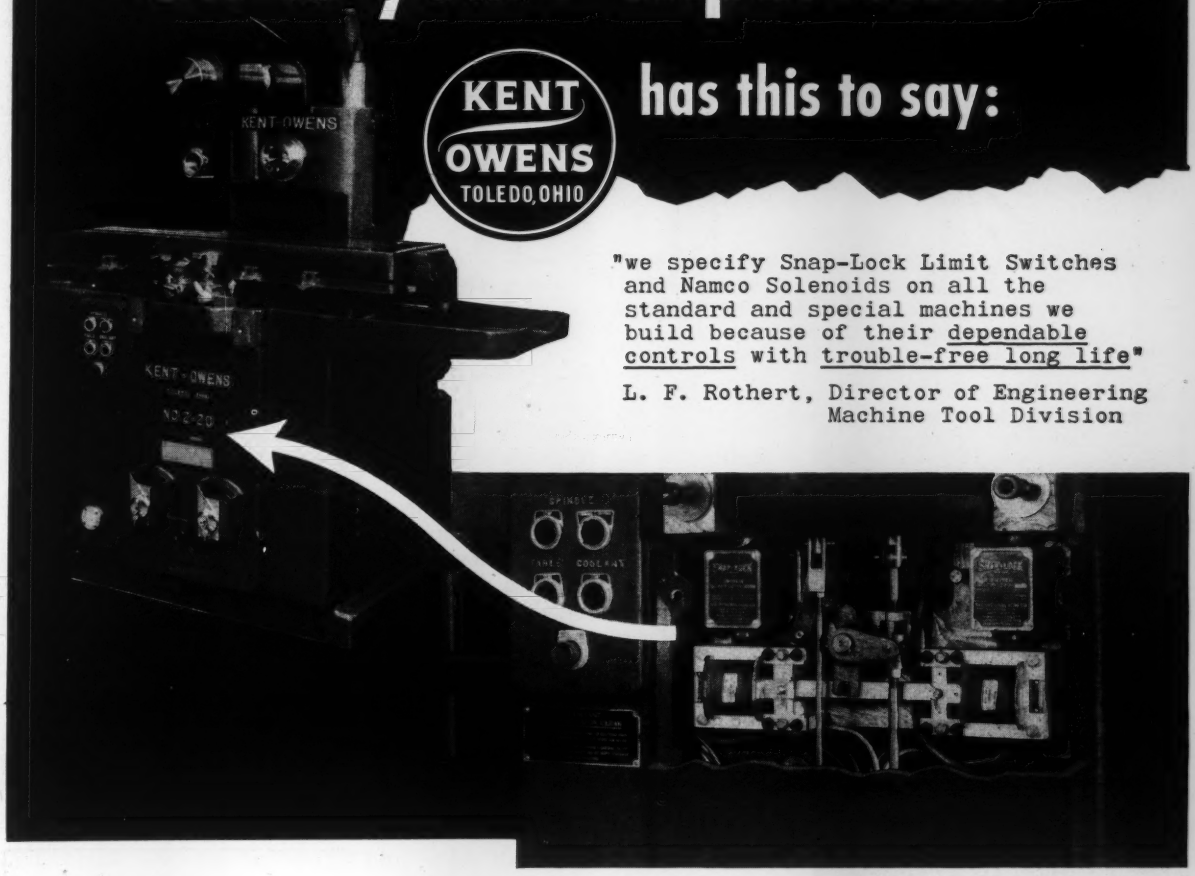
KENT OWENS TOLEDO, OHIO has this to say:



"we specify Snap-Lock Limit Switches and Namco Solenoids on all the standard and special machines we build because of their dependable controls with trouble-free long life"

L. F. Rothert, Director of Engineering
Machine Tool Division

NOTHING determines the efficiency of your production equipment, and the ultimate cost of its product, so much as the often hidden but vital controls that insure its split second precision, and elimination of down-time losses.

That's exactly the function and the guarantee behind Snap-Lock Switches, designed with separate sealed off mechanical sides, and of Namco "Stellite"-Weld Solenoids. Each is a patented product.

Built first to improve controls—"built with machine tool ruggedness"—for our own Acme-Gridley Automatics, these electrical devices are now specified as standard equipment by 90% of this country's machine tool builders alone. Army, Navy and Aircraft suppliers specify them used singly and in combination. Other uses in valves, clutches, switches and innumerable devices, number in thousands.

If you need to step up a cycle of operation—get rid of mechanical wear, save space and insure more dependable, continuous control of your production, ask our Engineers to help you "design one in" to your machine or process. Engineering specification catalogs—Limit Switches EM-51; Solenoid EM-52.

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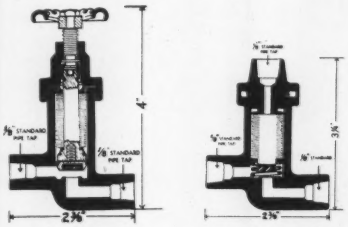
BAR and CHUCKING AUTOMATICS
1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • Limit, Motor Starter and Control Station Switches • Solenoids • Contract Manufacturing

The NATIONAL ACME COMPANY
170 EAST 131st STREET • CLEVELAND 8, OHIO

New Parts

pneumatic-hydraulic operated models are available, the former having a ball-joint which permits straight vertical thrust to be transmitted through the bellows and

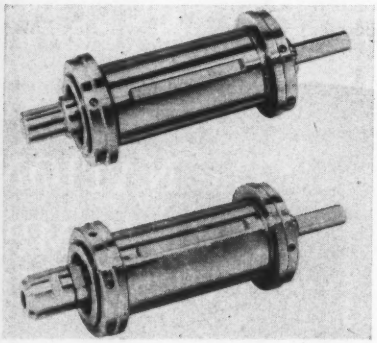


valve stem. All-metal construction makes valves suitable for high vacuum applications in laboratory equipment and for exhaust systems for hermetically sealed products. Valves to handle volatile liquids, gases or corrosive fluids can be furnished with bellows of such metals as stainless steel or Monel. Pneumatic-hydraulic operated model uses line pressures from 10 to 150 psi and has spring-loaded valve seat to insure positive opening. Inlet and outlet fittings are ⅛-in. female pipe tap on both valves. Made by **Clifford Mfg. Co.**, 152 Grove St., Waltham 54, Mass.

For more data circle MD-90, Page 191

Spindle Assemblies

Standard spindle assemblies for incorporation in special machines are available for either a No. 0 or 1 Morse taper shank, or ⅛, 3/16 or ¼-in. maximum capacity collets. Overall dimensions of the spindle assemblies range from 4⅝ to 8 in. long and from 1⅝ to



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Eaton Manufacturing Company
Fischer Special Mfg. Co.
Grip Nut Company
Milford Rivet & Machine Co.
Parker-Kalon Corporation
Ramsey Corporation
Russell, Burdsall & Ward Bolt & Nut Co.
Tinnerman Prods. Incorporated
Waldes Kohinoor Incorporated

In other sections of the File you will find additional catalogs containing useful information on product forms, characteristics, performance and use.

Sweet's Catalog Service

Division of
F. W. Dodge Corporation
119 West 40th Street, New York 18, N. Y.

Tracing design on glass cloth from metal loft at A. O. Smith Corp., Rochester Works.

Valuable originals protected against wear and tear

At the A. O. Smith Corp.'s Rochester (N.Y.) Works, large drawings are made exactly to scale on glass cloth. Since these drawings often cost several hundred dollars each, A. O. Smith naturally does not wish to expose them to possible damage during print-making and to the wear and tear of excessive handling. Instead, they use intermediates made on Kodagraph Autopositive Paper.

Costing but a few cents a square foot, Autopositive produces positive photographic prints directly from the original drawings — without a negative step or darkroom handling. It can be exposed in standard print-making equipment and processed in standard photographic solutions. (A. O. Smith uses a vacuum-frame printer, which accommodates drawings up to 8 x 4 feet in size.)

No worries with Autopositive intermediates — they turn out sharp, legible shop prints time after time. Their dense photographic black lines do not smudge or smear. And they can be run at uniform, practical speeds in the company's direct-process machine.

In addition, A. O. Smith keeps an "Autopositive File" showing the history of changes in all their drawings. Before each revision, an Autopositive intermediate is made. Later on, direct-process prints showing the complete story of each design can be made from the intermediates as needed.

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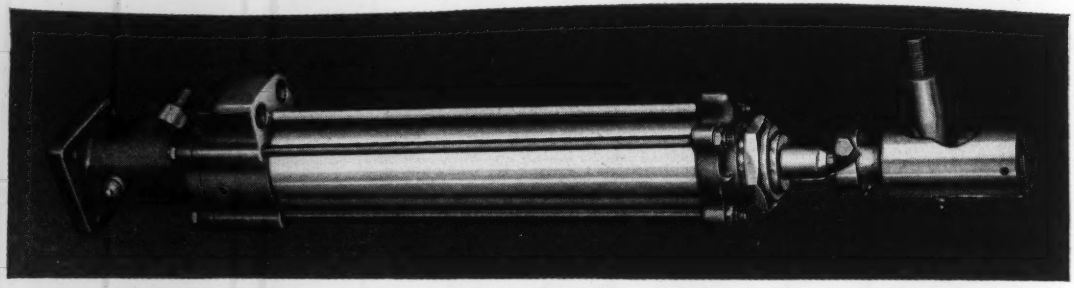
VOL. 2
Mobile Equipment News
VICKERS INCORPORATED, DETROIT, MICHIGAN
IMPROVES PERFORMANCE • CUTS COSTS
NO. 5

New! VICKERS® HYDRAULIC POWER STEERING BOOSTER...SERIES S23



LATEST DEVELOPMENT in POWER STEERING for TRUCKS, BUSES, MATERIALS HANDLING VEHICLES, ROAD CONSTRUCTION and MINING MACHINERY

More compact . . . improved in operating characteristics . . . this new Vickers Steering Booster, Series S23 is an important new development in power steering for many vehicles. Application is much easier because it requires less space . . . and ultimate costs are substantially lower. Series S23 thus opens the way to fingertip ease of steering for a wide range of additional vehicles.

Like the preceding models, Series S23 has hydraulic lock against road shock. Bumps, chuckholes, blown front tires, obstructions, etc., cannot spin the steering wheel or jerk it out of control. This is a safety factor of great importance.

In the interest of better operation and as a logical design improvement, the integral relief valve has been omitted from Series S23 and combined with a volume control valve. Vickers VT16 and VT17 pumps have integral volume control and relief valves. Where larger pumps are required, a separate combination valve is used (see Series FM2 below).

ASK FOR NEW BULLETIN M5106

MORE VERSATILE INSTALLATION

In Series S23 Boosters, the servo ball stud housing is symmetrical, and can be assembled in any one of four positions. This and the compactness of the Booster makes application easier . . . increases the number of applications which can be made without major engineering changes. Series S23 Booster may be mounted interchangeably with Series S6-270 Booster, however a relief valve must be provided either by use of VT16 or VT17 pumps or Series FM2 volume control and overload relief valve.

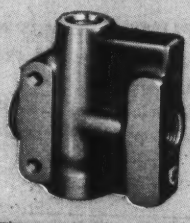
REQUIRES LESS SPACE

The new booster has been reduced in size by the redesign of the servo control valve. The tube connecting the servo valve to the rod end has been relocated and is now on the same side as the fitting connection. As a result of these changes, Series S23 requires less space . . . works in closer quarters.

6795

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1430 OAKMAN BLVD. • DETROIT 32, MICH.
Application Engineering Offices: ATLANTA • CHICAGO AREA (Brookfield) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • NEW YORK AREA (Summit, N. J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • TULSA WASHINGTON • WORCESTER

VICKERS® VOLUME CONTROL and OVERLOAD RELIEF VALVE



Five sizes of Series FM2 Valves were developed primarily for hydraulic power steering on trucks, buses and materials handling equipment where the pump does not include a volume control valve. The FM2 improves steering booster performance by providing a relatively constant volume of oil regardless of engine speed variations. An integral relief valve is included.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

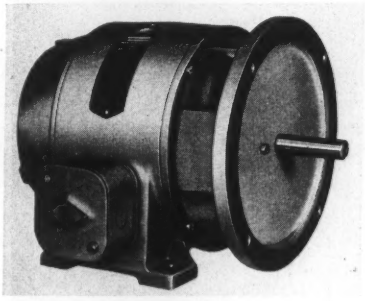
New Parts

2½ in. in diameter. Longitudinal adjustment of the spindle with relation to its mounting surface is provided by means of nuts at either end of the quill housing. Single row precision ball bearings at either end of the assembly are standard; double row bearings can be furnished. Bearings are double sealed, prelubricated and preloaded. A keyway is machined in the quill housing for locking it in the casting where the spindle assembly is to be mounted, and ground threads are provided for locking bearings in position. Made by **Russell T. Gilman Inc.**, 2410 N. Farwell Ave., Milwaukee 11, Wis.

For more data circle MD-91, Page 191

Torque Motor

While automatically adjusting its speed to intermittent load changes, this torque motor maintains a constant power. It can be stalled or "locked" with current on without damage to the motor.

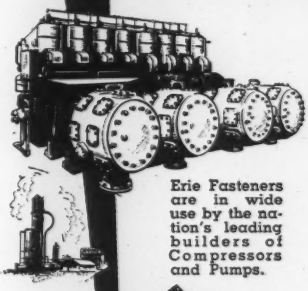


Standard units (with ratings measured in pound-feet of torque rather than horsepower) are available from ½ to 10 lb-ft with across-the-line locked service duty of 5, 10, 25, 50 and 100 per cent. Maximum stalls are 5, 10, 20 and 60 minutes and continuous, respectively. Torque motors are also available with right-angle worm or helical gear reducers. Applications include winding film or wire on spools; closing and holding closed electrical contactors, valves and locking devices; opening and holding open brakes; door operators;

(*Continued on Page* 218)

For DEPENDABILITY

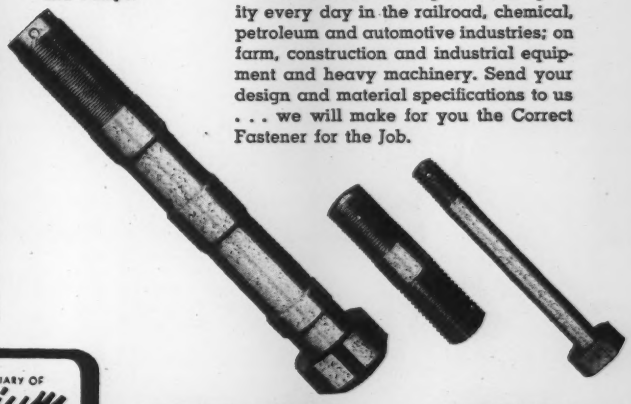
ERIE the correct fastener for the job!



Erie Fasteners are in wide use by the nation's leading builders of Compressors and Pumps.

You can rely on over 40 years of experience in producing bolts, studs and nuts designed to withstand the effects of high and low temperatures, high stresses, fatigue and corrosion. Modern facilities enable our skilled craftsmen to produce to your specifications bolts, studs and nuts, precision machined and heat treated in carbon, alloy, stainless steel and non ferrous metals.

These Erie Products prove their quality every day in the railroad, chemical, petroleum and automotive industries; on farm, construction and industrial equipment and heavy machinery. Send your design and material specifications to us . . . we will make for you the Correct Fastener for the Job.



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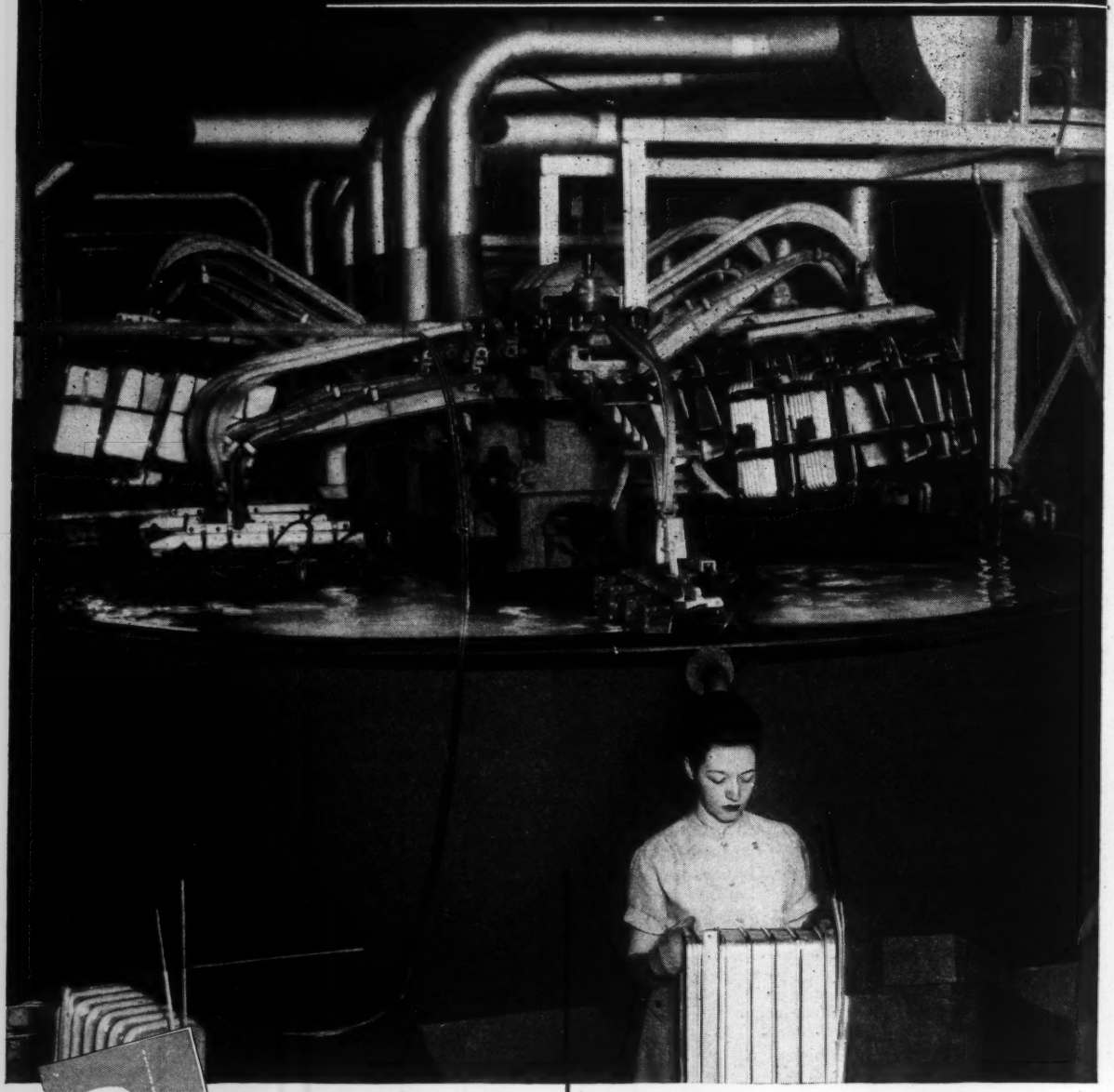

Write for your copy of the new 24-page "Catalog of Facilities." Get full details on the tremendous production facilities of Reynolds Aluminum Fabricating Service.

Here, embossed aluminum refrigerator evaporators are anodized on Reynolds modern equipment to assure maximum strength, corrosion resistance, rapid heat conduction, long lasting attractive appearance and economy. Majority of finishing operations at Reynolds are performed on automatic equipment to provide constant high quality finishes.

REYNOLDS ALUMINUM

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...Depend on Reynolds for

QUALITY FINISHES ON ALUMINUM PARTS PRODUCED TO YOUR SPECIFICATIONS

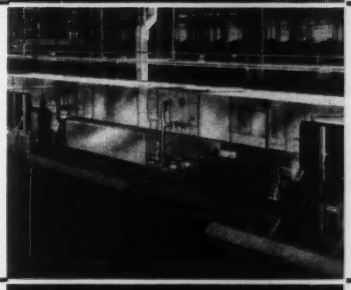
Mechanical • Chemical • Electrolytic • Organic

Reynolds Aluminum Fabricating Service offers excellent facilities for plain anodizing, color anodizing, alodizing, buffing, washing, degreasing, painting, oven-drying, infra-red baking and other finishing operations. Reynolds also offers you the advantages of years of experience with many finishing processes and materials that increase the natural corrosion resistance, increase abrasion resistance and augment the natural attractiveness of aluminum.

Whether your parts require mechanical, chemical, electrolytic, organic or other specialized finishes, the design and engineering assistance offered by Reynolds Aluminum Fabricating Service assures fast, economical, efficient service on your finishing needs. Reynolds experience and facilities also offer you the opportunity for greater variety of flexibility in your design ideas—along with the assurance of turning these ideas into high quality finished parts.

Remember—Reynolds design and engineering service, experience, facilities and quality control from mine to finished product are important advantages that you can count on in other operations, too. For full details, call your Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Kentucky.

Photograph shows step in buffing operation of aluminum deep well cookers produced by Reynolds Aluminum Fabricating Service for a range manufacturer.



Alodize system in a Reynolds plant used for alodizing continuous coils of aluminum which are later shipped as coils or cut and shipped as flat sheet.

Anodized aluminum washer and dryer tubs like these are produced to manufacturers' specifications by Reynolds Aluminum Fabricating Service.

See "Mister Peepers," starring Wally Cox, Sundays on NBC-TV.

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ROLL SHAPING • TUBE BENDING • WELDING • BRAZING • FINISHING

from Melt to Mechanism

Help for you . . . with micro-precision production

Hamilton Precision Service for all Industry

Turning
Milling
Threading
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backed by
Metallurgy
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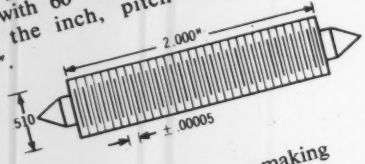
No. 578 the case of .00005" Tolerance Thread

Our Customer's Problem

To obtain precision threading on a shaft 2" long with 60° sharp "V" threads, 240 to the inch, pitch tolerance ±.00005".



Our Solution

Specially designed and built tap-making machinery; experience in quantity production of precision screws from 112 to 338 T.P.I. The Hamilton Standards Laboratory assures strict adherence to any customer specifications and enables us to make such parts easily and economically.

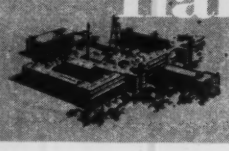
Your Problem

When you need fast production of small precision screws, "problem" parts, jewel bearings, or complex devices—machined to microscopic tolerances when necessary —assembled in any quantity—checked by extra-expert inspectors—guaranteed to do the job designed *every time* . . . call on Hamilton. Send your prints— we'll be glad to help you.

Allied Products Division

Hamilton Watch COMPANY

910 WHEATLAND AVE., LANCASTER, PA.



New Parts

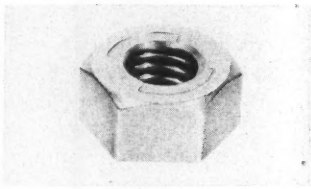
(*Continued from Page* 215)

machine tools and pumps. It is also suited for use as the second motor in a tandem installation. Made by **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif.

For more data circle MD-92, Page 191

Reusable Locknut

M-F Uni-Torque stop type, semi-finished locknut has part of the tap threads deflected slightly out of their true helix. Nut spins freely on the bolt until deflected threads are reached, then is secured in final position by wrenching. Seating is not necessary to



obtain lock. Produced in steel, brass, bronze, aluminum, stainless steel and other materials, nuts conform to American Finished and American Heavy standards. Sizes range in 1/16-in. increments, from ¼ to ⅝ in.; in ⅛-in. increments, from ¾ to 2 in. Threads in Finished series range from 28 to 12 NF, 20 to 4½ NC. In Heavy series threads range from 20 to 4½ NC. Made by **MacLean-Fogg Lock Nut Co.**, Dept. M., 5535 N. Wolcott Ave., Chicago 40, Ill.

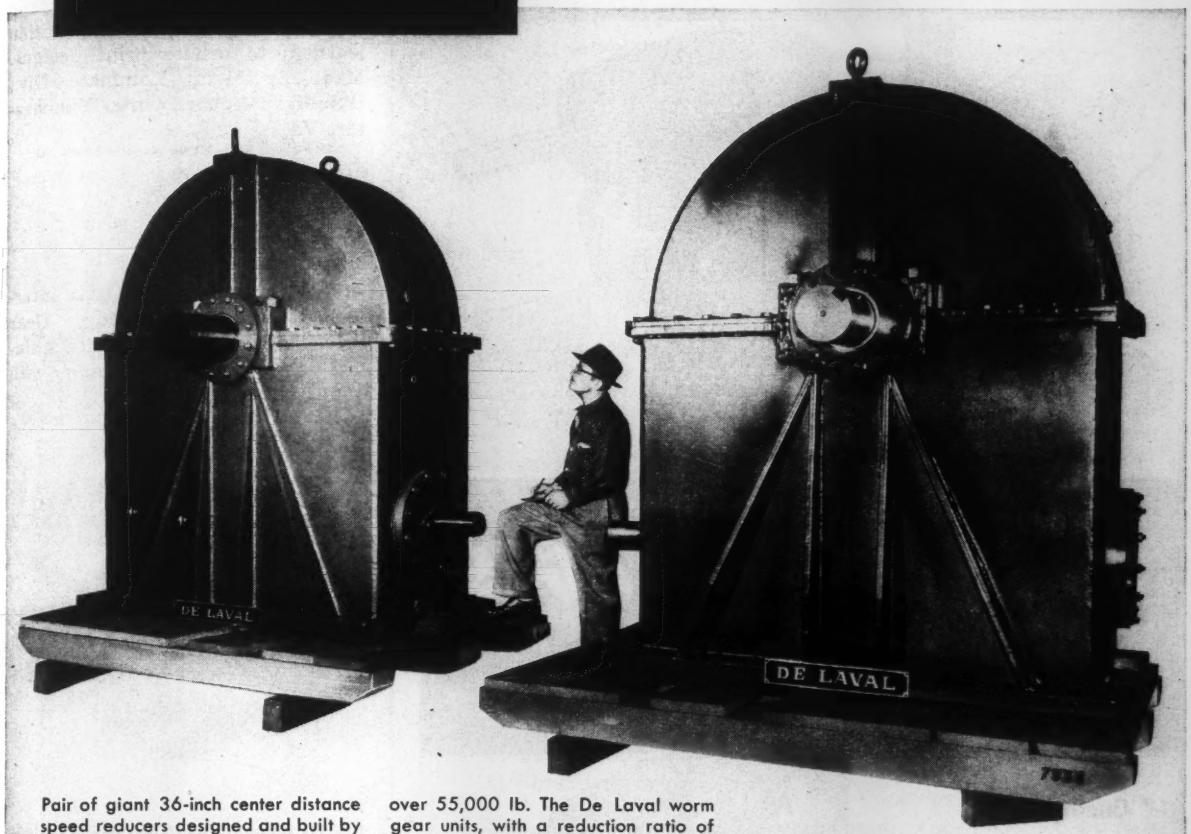
For more data circle MD-93, Page 191

Plastic Coated Metal

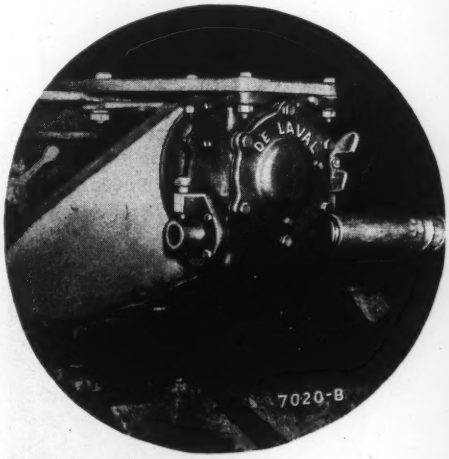
Sullvyne-Clad metal laminate, made by bonding vinyl plastic to steel, aluminum, magnesium, or copper sheeting, eliminates the need for finishing parts after fabrication. It can be bent, drawn, stamped, crimped, or punched without destroying either the vinyl or its bond. Welding of seams is possible since vinyl can be repaired at the point of weld to reconstitute the liner and lamination. Resistant to abrasion and corrosion, the

DE LAVAL
SPEED REDUCERS

from dwarf to giant size



Pair of giant 36-inch center distance speed reducers designed and built by De Laval for slab transfers in a slabbing-blooming mill. These slab transfers are used to convey steel slabs up to 12 in. thick and 42 in. wide, weighing over 55,000 lb. The De Laval worm gear units, with a reduction ratio of 26⅔ to 1 in a single set of gearing, are each driven by a 200 hp, 410 rpm motor coupled directly to the input shafts of the slab transfers.



Here's one of the smaller De Laval worm gear speed reducers with a 3″ center distance being used for a new coal drilling machine.

De Laval heavy-duty worm gear speed reducers seldom require attention under the most rugged operating conditions. They make a quiet, close-couple compact drive. They permit high ratio reductions in a minimum of space and withstand severe shock loads without damage. De Laval builds all sizes from 3″ to 36″ center distances for transmission ratios of 3.1:1 to 100:1 in single reduction units and ratios of 50:1 to 8000:1 in double reduction units. Whether you need dwarf or giant worm gearing, consult De Laval for engineering assistance. *Send for De Laval Manuals G-WBV and G-WWH containing data on single and double reduction units.*

DE LAVAL *Speed Reducers*

DE LAVAL STEAM TURBINE COMPANY

858 Nottingham Way, Trenton 2, New Jersey DL210

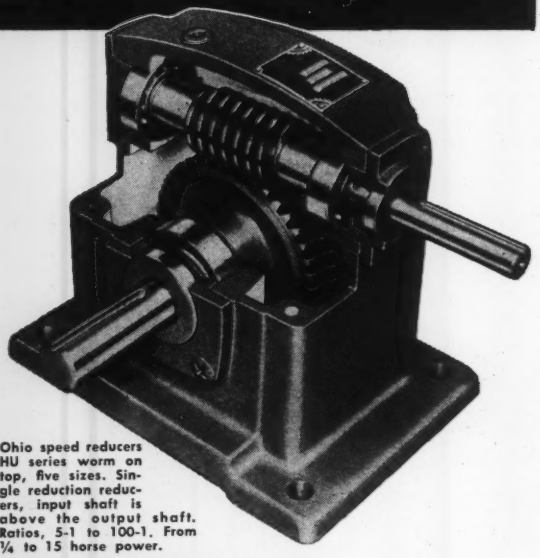
LOOK INTO YOUR
Speed Reducer Cost

Ohio double speed reducer DPL series, three sizes, ratios, 100-1 to 4000-1. From ¼ to 2½ horse power.

CHECK THESE ADVANTAGES WITH OHIO GEAR

- Quality
- Design
- Dependability
- Purchase Price
- Delivery

Ohio Speed Reducers are famous for their performance. You will find them operating in every great industrial center in the world. Perhaps Ohio Gear can serve you as well. There is a Distributor conveniently located near you—or write to Ohio Gear direct.



Ohio speed reducers HU series worm on top, five sizes. Single reduction reducers, input shaft is above the output shaft. Ratios, 5-1 to 100-1. From ¼ to 15 horse power.

ESTABLISHED 1915
OHIO GEARS

THE OHIO GEAR COMPANY, 1338 East 179th St., Cleveland 10, Ohio

New Parts

plastic coating withstands the effects of heat, light, and weather and is inert in the presence of most chemicals. Laminate can be processed in a variety of colors and in patterns ranging from imitation leathers to ornate print designs. Made by Metal Laminate Div., **O'Sullivan Rubber Corp.**, Winchester, Va.

For more data circle MD-94, Page 191

Hose Clamps

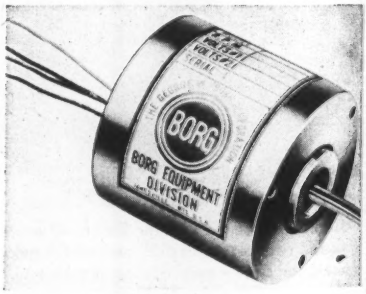
Hy-Gear hose clamps have interlocked band and housing. Gear drive clamps are offered with stainless steel band and housing with

plated screw and in an all stainless steel model for marine, plastic pipe, chemical and critical industrial applications. Made by **Ideal Corp.**, 435 Liberty Ave., Brooklyn 7, N. Y.

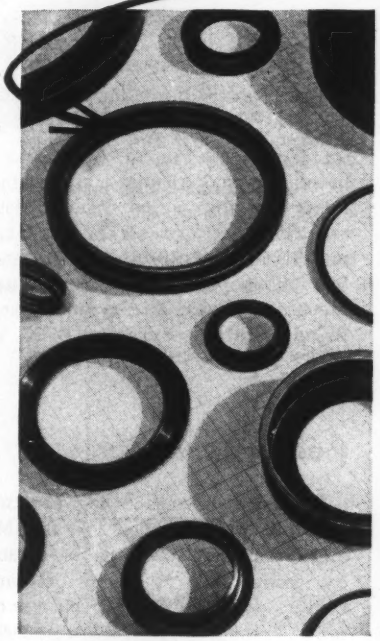
For more data circle MD-95, Page 191

Servo Motor

Model 1050 can be used in many servo applications or where a precision component is needed. Mo-



Take a look at These!



When the fabled Dutch Boy stuck his finger in the dike . . . he did a whale of a sealing job. But, when it comes to good seals for hydraulic and pneumatic equipment, *Houghton* has them. Here's how and why!

1. You name the shape and size—we make it.
2. Materials? Rubber, leather, or rubber-impregnated leather are Houghton specialties.
3. We are also manufacturers of Hydraulic Fluids—hence we know how they get along with packings . . . all about compatibility.
4. Houghton's VIM 1243-3 Rubber-Impregnated Leather Packing is the ONLY rubber-impregnated packing that has the sealing capacity of rubber PLUS the anti-friction qualities of leather, is *completely* flexible, and will not cold-flow.
5. We are field-represented by engineer-trained men who can give you all the benefits of our half-century in packings.

Have a packing problem? Call your Houghton Man—he'll be glad to show you sealing power that will solve your packing troubles—for good—no obligation, of course. Or write direct to E. F. Houghton & Co., 303 W. Lehigh Avenue, Phila. 33, Pa.

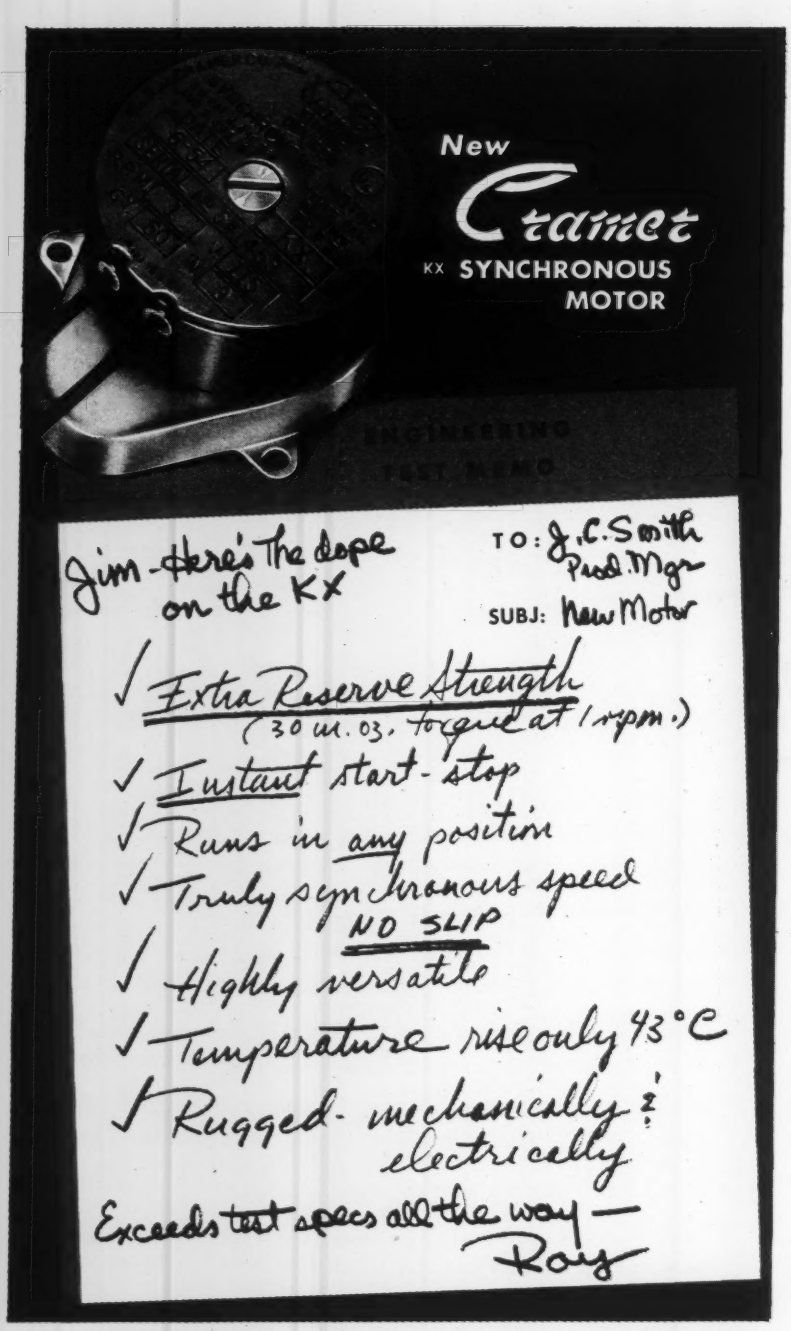
VIM and VIX-SYN PACKINGS

. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



This does not tell the whole story by any means, but it does indicate the growing acceptance of this powerful motor for all types of instrument and control applications which require constant speed and dependability even under adverse environmental conditions. The complete story is yours for the asking. Write today.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

W. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

10CR54

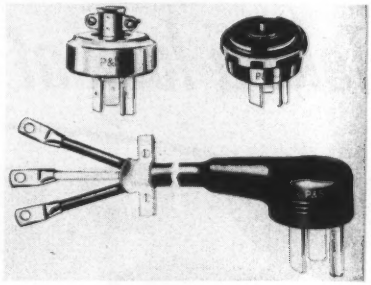
New Parts

tor is of the induction type and operates on two-phase, 115 v, 400-cycle ac. Minimum locked rotor torque is 0.82 oz-in. in either direction when operated at 115 v. No-load speed is 550 rpm. Motor measures approximately 1½ in. in diameter, 1½ in. long, with ½-in. shaft extension. Made by Borg Equipment Div., **George W. Borg Corp.**, Janesville, Wis.

For more data circle MD-96, Page 191

Three-Wire Plugs, Cords

Line of 30-amp three-wire plugs and cord sets have L-shaped blades. Cord grip plugs are made



in plastic and armored styles, the latter having a corrosion-resistant finish. Cord set is available in 36, 48 and 60-in. lengths and has nonseparable rubber plug. Made by **Pass & Seymour Inc.**, Solvay Station, Syracuse 9, N. Y.

For more data circle MD-97, Page 191

Pressure Switch

Pressure difference between two variable pressures, or a variable and reference pressure is sensed by model 532 Meletron pressure switch, available in four classes of proof pressures from 500 to 12,000 psi. Switch operates relays, solenoids, motor controls and similar devices, permitting opening or closing of circuit on increasing or decreasing pressure difference from 15 to 10,000 psi at any point within unit's adjustable range. Two highly accurate parallel bourdon tubes comprise sensing element. Unit operates in any position and

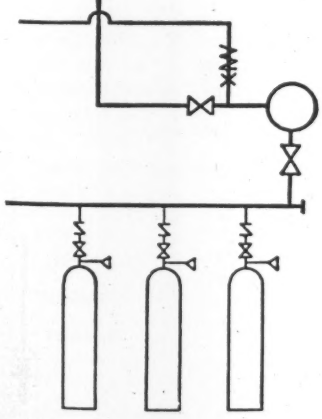
This "Hospital Valve" for **OXYGEN** now serves many industrial needs . . .

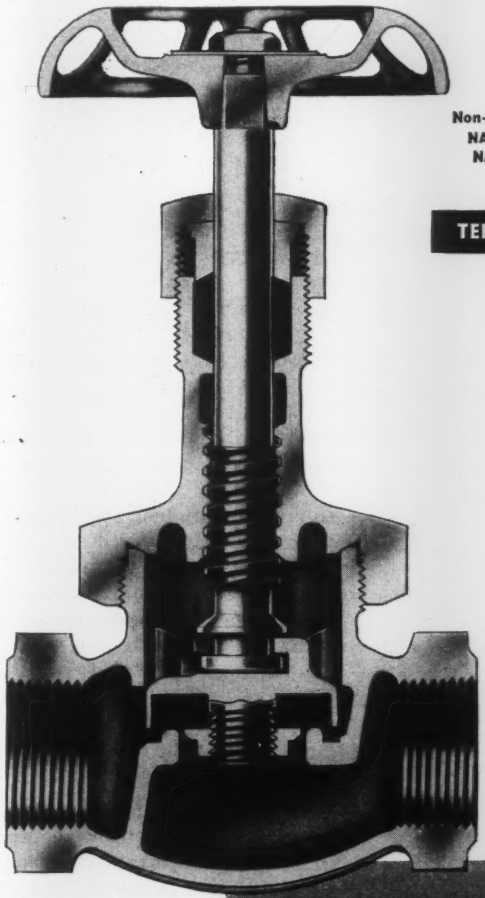
JENKINS Fig. 504 Bronze Globe with **TEFLON** disc and packing

Jenkins Fig. 504 was designed for the critical requirements of controlling oxygen, nitrous oxide, or any non-flammable gases in hospital services. Industry was quick to note its unique advantages, and it is now frequently specified for systems carrying gaseous fluids for heating, cooling, lighting, and processing, where pressure does not exceed 400 psi, or temperature a maximum of 150° F.

Fitted and tested to comply fully with all Association specifications for hospital services, Fig. 504 has the "extra value" construction throughout that is assured by Jenkins quality standards.

Get details — find out how Fig. 504 can improve efficiency and economy in your hookups for critical service. It's another example of the broad range of "valves for every service" in Jenkins' complete line.





Complies fully with "Standards for Non-Flammable Medical Gas Systems" of—
NATIONAL FIRE PROTECTION ASSOCIATION
NATIONAL BOARD OF FIRE UNDERWRITERS
AMERICAN HOSPITAL ASSOCIATION

TEFLON Disc and Packing

DuPont "Teflon" is a tough, "waxy" inert solid, gray-white in color, tasteless and odorless, non-adhesive and frictionless. Teflon's high resilience assures perfect contact of disc with lapped, crowned seat for gastight closure. Packing is one-piece ring of Teflon, provides dependable leak-proof seal with light compression.

Reinforced Body Casting
High strength bronze body is ribbed along bottom centerline providing extremely high factor of safety. Guards against distortion from vibration, shock, or pipe strains.

Degreased
All bronze parts are thoroughly degreased before assembly.

Polished Spindle
Alloy bronze spindle is polished to permit easy turning and assure leak-proof seal.

Sizes
— ¼" to 2" — 400 lb. O.W.G.

GET COMPLETE INFORMATION from your Jenkins Valve Distributor, or write: Jenkins Bros., 100 Park Ave., New York 17. Ask for Bulletin 116.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
TRADE JENKINS MARK

SOLD THROUGH LEADING INDUSTRIAL DISTRIBUTORS EVERYWHERE

What does "S. B." mean to you?

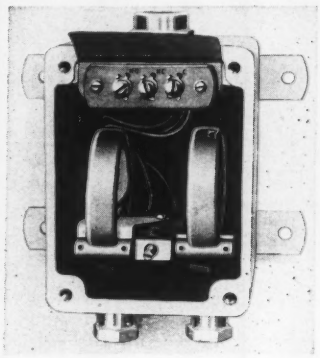
To some, it means "Sales Boom" . . . a natural corollary to using finer materials. And, to thousands, it means "Small Balls" produced by Universal Ball Company and definitely tied in with Sales Booms.

Sure, we make the larger sizes too, but Universal is getting a universal reputation for these Small Balls of such superb accuracy. Want to roll it around and then get in touch with us?

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

New Parts



is housed in splashproof enclosure. Underwriters' approved snap-action, single-pole, double-throw switching element for ac and dc circuits is employed. Made by **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

For more data circle MD-98, Page 191

Epoxy Resin

Hysol 6000HD has a heat distortion temperature of over 150 C and is dark transparent amber in color. It is supplied as sheets, rods, and tubes or custom castings made to specification. Electrical properties and machinability are good, and water absorption is low. A companion product, Hysol 6040 and hardener AN, is used as a potting compound. It has a heat distortion temperature of 120 C. Made by **Houghton Laboratories Inc.,** 322 Bush St., Olean, N. Y.

For more data circle MD-99, Page 191

Miniature Relay

Hermetically - sealed telephone type relay is able to withstand high shock and vibration because of ample reserve power in the coil. Relay meets the requirements of MIL - R - 5757 and MIL - R - 6106. Standard contacts are palladium; silver contacts are supplied when specified. Standard contact model is rated at 2 amp, 115 v, 60-cycle ac or 28 v dc noninductive. Maximum switching combination is four-pole, double-thow. Either solder lug or plug-in terminals may be furnished, and coils are

. . . if only for THEIR sakes

. . . learn how to protect yourself from death from cancer. They need *you!*

And for your sake and theirs you must keep on remembering that the best cancer "insurance" is:

FIRST . . . *to make a habit of periodic health check-ups no matter how well you may feel, always including a thorough examination of the skin, mouth, lungs and rectum and (for women) the breasts and generative tract.*

SECOND . . . *to learn the seven danger signals that may mean cancer, and go straight to the doctor at the first sign of any one of them—(1) Any sore that does not heal (2) A lump or thickening, in the breast or elsewhere (3) Unusual bleeding or discharge (4) Any change in a wart or mole (5) Persistent indigestion or difficulty in swallowing (6) Persistent hoarseness or cough (7) Any change in normal bowel habits.*

For other life saving facts about cancer, phone the American Cancer Society office nearest you, or address your letter to "Cancer"—in care of your local Post Office.

American Cancer Society

DU PONT
REG. U.S. PAT. OFF.

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

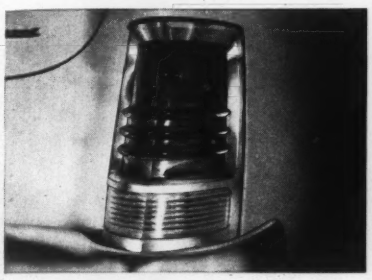
NEWS

NO. 5 — 1954

Windshield-wiper Motor of Du Pont "Zytel"* Nylon Resin Shows No Wear after 9,500,000 Cycle Test

Du Pont LUCITE® gives long-lasting sparkle to molded parts

DU PONT "Lucite" acrylic resin has optical and mechanical properties which make it a versatile engineering material. "Lucite" is readily injection-molded,



A clear, shatter-proof, corrosion-resistant taillight lens of Du Pont "Lucite". The wide range of applications for "Lucite" acrylic resin in the automotive field are indicative of the usefulness of this material to the design engineer.

providing economical production of parts, in simple or complex shapes. This engineering material has unique "light-piping" and "edge-lighting" qualities, and is available in a wide range of colors.

(Continued on Page 2, Column 1)

Unique engineering material has outstanding abrasion resistance and is lightweight and dimensionally stable.

Exploded view of air-pressure windshield-wiper motor of Du Pont "Zytel" nylon resin. These parts resist corrosion and are lightweight. They are injection-molded and require no finishing operations. The manufacturer is Sprague Devices, Inc., Michigan City, Indiana. Molder is Danielson Company, Danielson, Conn.

WINDSHIELD-WIPER failure on a truck can mean costly delay. Now an air-pressure wiper motor has been developed that's much less subject to failure than old-style motors. Its parts are molded of Du Pont "Zytel"* nylon resin.

This motor weighs only 10 ounces—yet is so durable that the manufacturer claims it will outlive any truck. In a grueling test, the motor operated two wiper arms and blades for 9,500,000 cycles. Afterwards, the parts of abrasion-resistant "Zytel" showed no perceptible wear.

Corrosion, too, is no problem with "Zytel". And the motor parts won't leak air—keep dimensionally stable when exposed to temperature and humidity changes.

No Finishing Necessary

Parts for this motor are mass-produced by precision injection molding. Their smooth, resilient surfaces are ideal for handling moving seals. The manufacturer can keep down production costs because expensive surface-finishing operations are eliminated.

Have you and your company investigated the properties of Du Pont "Zytel" nylon resin? The application shown here is typical of the prod-

(Continued on Page 2, Column 1)

*"Zytel" is the new trade-mark for Du Pont nylon resin.

OVER

Construction well along on $3,000,000 Polychemicals laboratory in Wilmington

DU PONT is building a $3,000,000 Sales Service Laboratory in Wilmington, Delaware, to expand the present facilities of its Polychemicals Department. This new laboratory is to provide sales and engineering services to customers in the plastics and other industries.

The laboratory will have the most modern equipment available for developing technical data on the use and processing of Polychemicals Department products. Its facilities for providing technical services, especially in the field of plastic engineering materials such as "Alathon" polyethylene resin, "Teflon" tetrafluoroethylene resin, "Lucite" acrylic resin, and Du Pont "Zytel" nylon resin, will be several times those of the present laboratory in Arlington, N. J.

Parts of the new laboratory will be equipped especially for study courses on the utilization of new plastic engineering materials. Space for exhibits of these materials and products made from them is provided in a two-story reception area.

Large portions of the laboratory will be equipped for demonstrating new processing methods and for testing. Total floor space: 62,000 square feet.

Preliminary work on the site is now under way and construction is expected to be completed late in 1954.

DU PONT
REG. U. S. PAT. OFF.

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

PLASTICS NEWS

NO. 5 — 1954

Wiper Motor of "Zytel"

(*Continued from Page 1*)

uct improvement possible when the properties of this unique engineering material are evaluated in terms of design and service requirements. For further information, clip the coupon.

Du Pont "Lucite"

(*Continued from Page 1*)

Stays Clear and Sparkling

Du Pont "Lucite" has exceptional outdoor stability . . . stays clear and sparkling when constantly exposed to sunlight and moisture. Also, lightness of weight and shatter-resistance are desirable features of Du Pont "Lucite".

Easily Molded

"Lucite" is readily molded or extruded to desired shapes. There are many applications for "Lucite" such as automotive, medical, illumination, decorative, to mention a few. For complete information on this versatile member of the Du Pont family of plastic engineering materials fill in the coupon on this side of this page today.

Investigate Du Pont engineering materials in your product development programs

ONE of the family of these versatile engineering materials is often a key factor in product improvement or new product design.

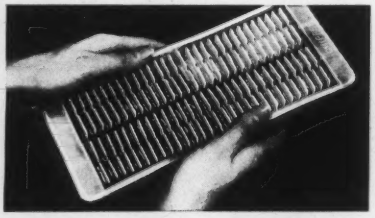
The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"** nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION?

CLIP the coupon for additional data on properties and applications of these Du Pont engineering materials.

New flexible ice tray made of Du Pont "Alathon"

DU PONT "Alathon" polyethylene resin has again demonstrated its versatility—this time as a flexible ice tray that supplies chipped ice when it's twisted. The Gits Molding Corp., manufacturers of "The Chipper", report they are using "Alathon" 10 for this ice tray because this Du Pont engineering resin material offers advantages found in no other material.



Chipped ice at her fingertips—with a simple twist of this tray of "Alathon" polyethylene resin. "The Chipper" is made of Du Pont "Alathon" 10 by Gits Molding Corporation, Chicago, Illinois.

Properties of "Alathon"

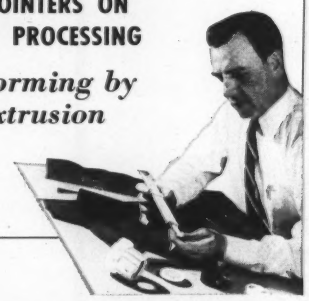
Du Pont "Alathon" stays flexible at temperatures well below those at which the ice tray is used. "Alathon" is warm to the touch . . . more pleasant to handle. "Alathon" contains no plasticizer—it won't affect the taste of the ice, and is odorless and non-toxic. These "Chipper" trays are mass-produced by the economical injection-molding technique.

Can "Alathon" Help You?

If you have a design problem, perhaps Du Pont "Alathon" polyethylene resin is just the material you've been looking for. Every day, designers are finding more and better ways to use this versatile engineering material. For complete information on the properties and applications of "Alathon", use the coupon.

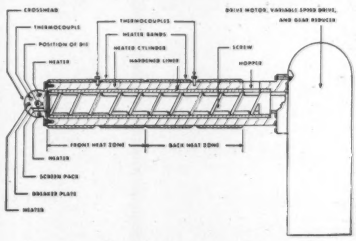
POINTERS ON PROCESSING

Forming by Extrusion



DU PONT "Zytel" nylon resin, "Teflon", "Alathon" and "Lucite" all can be formed by extrusion techniques. Basically, screw extrusion consists of placing the granulated material in a hopper where it is moved down and forward along a one-piece heating barrel by means of a rotating screw. The screw then forces the softened material through a die, forming it into shapes such as tubing, rod, bars, and other shapes. This operation varies in a minor degree with the material being processed. Screw extrusion is applicable to "Alathon", "Lucite" and "Zytel".

A typical extrusion machine for "Zytel" nylon resin has these features:



Extrusion of "Teflon"

Extrusion of "Teflon" is best carried out by the ram extrusion method. A reciprocating ram in a cylinder compacts successive charges of "Teflon". The powder is introduced through a hopper at the back position of the ram. Preforming takes place at a cold section of the cylinder and the compacting material moves through the heated section of the cylinder where it is sintered.

Extrusion has certain economic advantages where continuous lengths of material are desired. For example, a coating of "Zytel" nylon resin used as a primary insulation on small wire can be applied at speeds up to 1600 feet per minute with suitable take-off equipment.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 128, Du Pont Building, Wilmington 98, Delaware.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel";* ☐ *"Alathon";* ☐ *"Teflon";* ☐ *"Lucite". I am interested in evaluating these materials for:*_____

NAME_____ POSITION_____

COMPANY_____

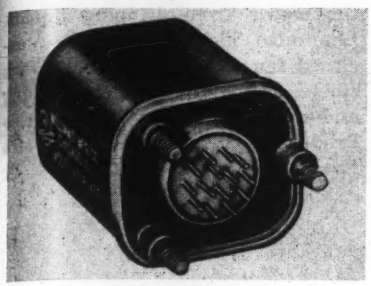
STREET_____

CITY_____ STATE_____

TYPE OF BUSINESS_____

*"Alathon", "Lucite", "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)
**"Zytel" is the new trade-mark for Du Pont nylon resin.

DEPARTMENT OF TECHNOLOGY
MASS. INSTITUTE OF TECHNOLOGY LIBRARY

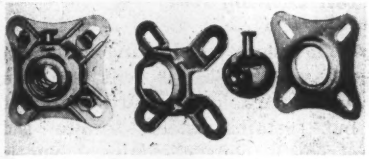


available with resistance from 12 to 3600 ohms and for voltages from 6 to 115 v. Maximum power consumption is 4 w. Relay measures 1⅝ x 1 7/16 x 2 in. Made by Sealectric Switch and Relay Div., **Williams Mfg. Co.**, 4242 Fillmore St., Chicago 24, Ill.

For more data circle MD-100, Page 191

Flange Bearing Assembly

Four-bolt flange pillow block assembly is now available for shaft sizes from ½ to 1 in. Compact and lightweight, it features "deep well"

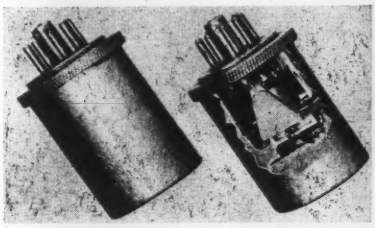


lubricated ball assembly with graphited bronze bushing to assure long, trouble-free service. Slotted bolt holes facilitate interchangeability with other units having hole centers of 2⅛, 2¼ and 2¾ in. Inner and outer housing of 14-gage steel has die formed races for good alignment. Bearing is also available with sintered bushings for light duty application. Made by **Randall Graphite Bearings Inc.**, Greenlawn and Lake Ave., Lima, O.

For more data circle MD-101, Page 191

High Sensitivity Relay

Balanced armature, permanent magnet type relay is highly sensitive and can be used for temperature alarm or detection or in other applications requiring precise regulation. It is internally shock mounted and resistant to vibration. Screw-on cover is gasket sealed. Relay sensitivity permits infinite variations from 0.2 microamperes to 10 amp or from 0.1 mv to 500 v. Accuracy is about 1 to 2 per cent, and response time is variable from 50 operations per second to 5 seconds time delay. SPST or SPDT contact arrangements are available. Standard rating is 5 to 25 milliamperes dc, and ratings to ½-amp are available. Standard relay

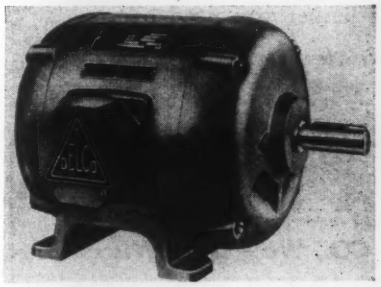


mounting is a nine pin octal style plug. Made by **Assembly Products Inc.**, Main at Bell St., Chagrin Falls, O.

For more data circle MD-102, Page 191

Squirrel-Cage Motors

Line of ac squirrel cage induction motors is made in frame sizes from 182 through 326, to meet new NEMA standards on rerated frame sizes. Illustrated is the open drip-proof motor which has cast-iron main and end frames, aluminum die-cast rotors, grease lubricated double shielded ball bearings, Delcote cotton and varnish insulation and a drip-proof baffle cast as part of the end frame, which protects



Designed and engineered with the user in mind, O-M Cylinders embody every essential construction and mechanical feature to assure trouble-free performance and long service.

They are built of steel with bearing surfaces of bronze—precision machined with modern equipment.

Cylinder bores are honed to a fine finish, and the hi-tensile piston rods are polished to give long life and smooth performance.

Effective O-ring static seals are backed up to prevent extrusion under high pressures. All packings are self-adjusting and are carefully selected for proper usage.

A rigid inspection at the factory is your guarantee of peak performance.

O-M Cylinders fit where others won't because O-M special interlocking mechanism eliminates bulging tie rods and end caps.

Available in a full range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. *14-day delivery on most sizes.*

Write today for FREE catalog and complete set of ½ and ¼-scale templates showing all cylinders and mounting brackets.

MAIL COUPON NOW!

ORTMAN-MILLER MACHINE CO.
1210 150th Street - Hammond, Ind.

☐ Please have representative call
☐ Please send latest catalog

Name _____
Company _____
Address _____
City _____ Zone ____ State _____

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"Bonded for Life!"

In Waukesha Sleeve Bearings, Split Bearings, and Oil Seals, the bond between babbitt and bearings never fails. The Waukesha Centri-fuse Process results in an actual chemical bond — a liftime metal-to-metal fusion of babbitt and backing — whether the backing is bronze, steel, cast iron or aluminum.

Remember, too, that Waukesha's complete manufacturing facilities and Waukesha engineering counsel are at your service whether you need *one bearing or a long production run.*

WAUKESHA Bearings

Division of WAUKESHA TOOL CO., Waukesha, Wisconsin

A 7931-2/3

New Parts

the motor from dripping liquids. Line also includes a totally enclosed fan-cooled motor built with ribbed frame for efficient cooling and easy cleaning. Made by Delco Products Div., **General Motors Corp.**, 329 E. First St., Dayton 1, O.

For more data circle MD-103, Page 191

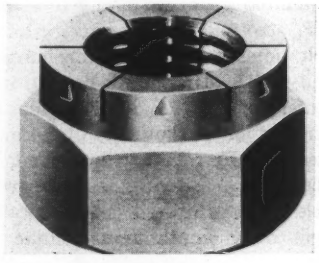
Metal Powder

Plast-Iron B-212 reduced oxide compacting powder is formulated for manufacture of mechanical parts requiring very high tensile and transverse strengths and good wear resistance but not unusual ductility. Material can be made to show narrowly restrained growth on sintering by the addition of small percentages of copper. Specimens containing only 3 per cent copper are reported to be equivalent in strength to conventional powders with 10 per cent copper. Made by Plastic Metals Div., **National Radiator Co.**, Johnstown, Pa.

For more data circle MD-104, Page 191

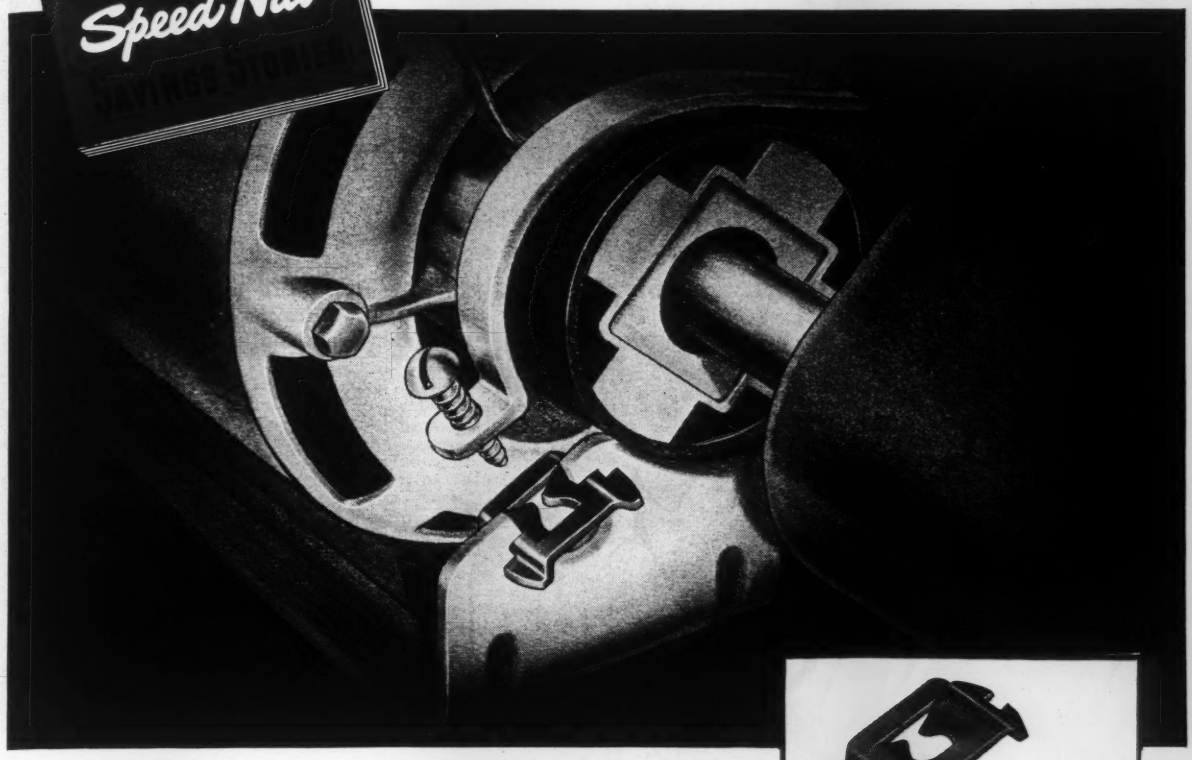
Self-Locking Nut

One-piece self-locking aluminum nut weighs 65 per cent less than a comparable standard steel nut but retains steel torque and strength characteristics. Nut is made from 24ST aluminum and is



suitable for service at temperatures to 250 F. Nut, which can be reused without loss of locking efficiency, is chemically treated against corrosion. Spring tension of resilient segments of the locking section secure the nut at a desired position whether it is seated or not. It is available in 6-32,

FASTEST THING IN FASTENINGS®



"EASY does it" with SPEED NUTS®

...cuts assembly time 87%!

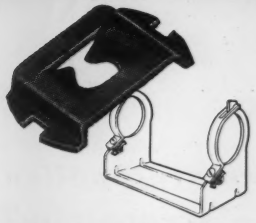
Easy Spindrier

What was causing delays in the production of the new Easy Spindrier? Easy engineers recently found out in a hurry. It was the motor mount bracket assembly. A staking operation was creating a decided bottleneck.

Borrowing on their own long-time experience with SPEED NUT brand fasteners—and the help of the Tinnerman field engineer—they hit on a highly successful solution using a special Flat-Type SPEED NUT!

Proof of the success was supplied through a startling 87% saving in production time—and an overall cost savings of 47%!

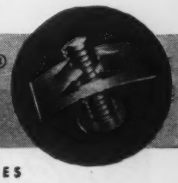
Little wonder, then, that Easy engineers saw to it that over 60 SPEED NUTS were designed into the new Easy Automatic Washers.



Special self-retaining Flat-Type SPEED NUT snaps easily into existing notch in bracket. Replaces round nut which was staked down, often causing distortion of nut—this meant re-tapping. Also, paint clogged around nut, causing screws to bind. Paint can't clog SPEED NUTS.

Send today for your copy of SPEED NUT "Savings Stories"; write: TINNERMAN PRODUCTS, INC., Department 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Limited, Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine).

TINNERMAN Speed Nuts®



MORE THAN 8000 SHAPES AND SIZES

The Known Dependability of

Manzel

FORCE FEED LUBRICATORS

Helps put sales appeal in the equipment you design.

Pressure Application – Exact Amounts – Accurately Timed

● Machinery and equipment buyers know the vital operating importance of correct lubrication. When you design with Manzel Force Feed Lubricators, you build instant sales appeal into your products. Any number of points can be lubricated with round-the-clock precision and dependability against pressures as high as 30,000 P. S. I. G. Manzel Lubricators cost surprisingly little for the big job they perform. And remember, the Manzel organization can engineer special applications to your special needs. Write for details.

Manzel

DIVISION OF FRONTIER INDUSTRIES, INC.
276 Babcock Street Buffalo 10, New York

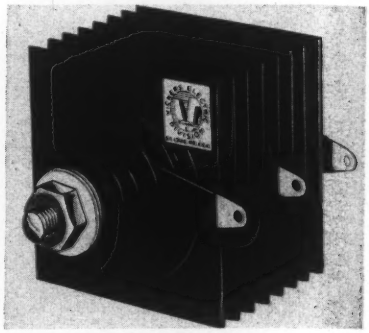
New Parts

8-32, 10-32, ¼-28 and 5/16-24 sizes. Made by **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

For more data circle MD-105, Page 191

Selenium Rectifier

With an inverse cell rating of 40 v, this selenium rectifier combines low leakage; low inverse loss, with heating as a result of low inverse loss at high voltage averaging less than 5 C; and high

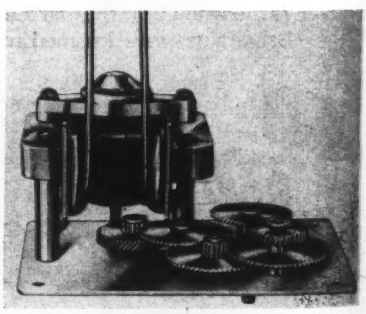


dielectric quality, with ability to withstand surges up to twice rated voltage. It is said to operate at ambient temperatures up to 125 C, with no derating for 50 C. Life of the rectifier is approximately 25,000 hours. Made by Vickers Electric Div., **Vickers Inc.**, 1817 Locust St., St. Louis 3, Mo.

For more data circle MD-106, Page 191

Gear Train and Motor

Quiet operation of this assembly is achieved through the cut of the gears and pinions. Motor operates



BUILT-IN EFFICIENCY

■ Every Lamson fastener is designed to serve a particular application. For maximum efficiency, most economical assembly and most satisfactory appearance, choose the fastener that's "right for the job".

The fasteners shown here each have their place in your assembly line. Choosing the right fastener for the right job is one way to take advantage of their "built-in efficiency".

PHILLIPS HEAD

There are many reasons behind the design of the Lamson Phillips head. The "X" slot really clings to the driver bit for faster assembly. They are self-aligning and straight-driving, perfect for spiral or power drivers. They draw up tighter than a slotted head, without head loss or damage and they offer the best appearance on the finished job. These advantages are yours when you specify Lamson Phillips Head tapping screws and machine screws. Available in flat, round, oval, fillister, pan and truss head shapes.

SPIN LOCK

Lamson Spin Lock fasteners are designed to "bite" and hold. The ratchet-like structure of the teech prevents "backing off" when the fastener is set. This, obviously, makes for very high holding power. Five head styles: hex, pan, truss, flat and large flat. For tapping screws and machine screws that are vibration proof, easy driving, water and oil tight around the head and that tighten flush to surface, specify Lamson Spin Lock.

SEMS

These pre-assembled washer and screw units can really save you time. No fumbling for washers, no doubling of inventory and no special assembly techniques are just a few of the advantages. Sems are available with two washer types; toothed washers and helical spring washers, and a broad variety of screws. Head styles include flat, oval, truss, pan, round, fillister and hex.

CLUTCH HEAD

The straight-walled, shallow recess design of the clutch head offers real advantages in assembling procedures. The recess centers the driver. Because the slot is not tapered, any tendency for the driver to "climb out" is held to a minimum. This means greater safety and less driver pressure to draw up the fastener. The periphery of the head is unbroken, which means that you get a stronger screw, size for size, than any other type. In an emergency, Clutch heads can be serviced in the field with a common screw driver.

Complete information on these Lamson fasteners is yours for the asking

The LAMSON & SESSIONS Co.
1971 West 85th St. • Cleveland 2, Ohio
Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Lamson + Sessions

FOR PROMPT DELIVERY AND HELPFUL SERVICE, ORDER FROM YOUR LAMSON DISTRIBUTOR

PLUG NUTS
Ideal for blind or hard-to-reach places.

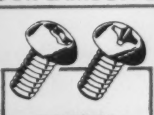
PIPE PLUGS
Forged steel, heat-treated.

"1035" SET SCREWS
Cup point type, hardened and heat-treated.

PLACE BOLTS
With "Built-in" spring action for positive locking.

LOCK NUTS
Economical, vibration proof. Can be used repeatedly.

"BENT BOLTS"
Including U bolts, eye bolts, hook bolts, etc.



MACHINE SCREWS
Clutch and Phillips recessed head screws.

SEMS
Pre-assembled lockwashers on tapping and machine screws.

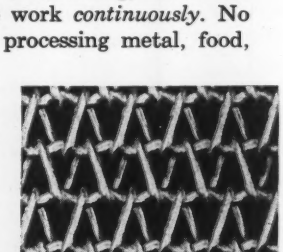
idea for AUTOMATION

with CAMBRIDGE
Woven Wire Conveyor Belts

CONTINUOUS BRAZING

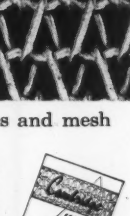
Metal products can be heat treated, quenched and cooled in one continuous series of operations on Cambridge belts. All-metal belt is unharmed by temperature, quench oils or sharp-edged, heavy loads. Working in process temperatures from sub-zero to as high as 2100° F. . . . and in dry or highly corrosive conditions . . . you'll find Cambridge Woven Wire Conveyor Belts help provide cost-cutting, automatic production by allowing you to process the work *continuously*. No batch operations, less manual handling in processing metal, food, chemical or ceramic products.

OPEN MESH CONSTRUCTION of belt provides free circulation of process atmospheres for uniform treatment, free drainage of process solutions. Of course, the all-metal construction means lowest maintenance cost.



CAMBRIDGE BELTS are available in any metal or alloy. Thus, the belt recommended for you can be fabricated from the specific material that will give longest belt life under your operating conditions. In addition, Cambridge belts can be woven to any length or width and in a wide variety of weaves and mesh sizes to meet your needs.

FREE REFERENCE MANUAL gives full details on how Cambridge belts can boost output, cut costs by providing continuous, automatic production . . . *automation!* Includes all specifications and details, also metallurgical tables. Write for your copy today! Or, for specific recommendations, call in your Cambridge Field Engineer. He's listed under "Belting-Mechanical" in your classified 'phone book.



The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N
Cambridge 8, Maryland

OFFICES IN LEADING INDUSTRIAL AREAS

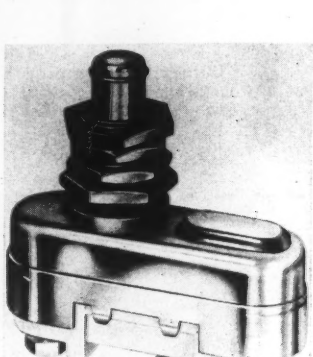
New Parts

in range of 1 to 194 rpm, provid ing either clockwise or counte clockwise rotation. Torque at rpm is 60 lb-in. Operating on 11 v, 60-cycle ac, the shaded-pole mo tor has die-cast bearing bracket internal cooling fan and self align ing oil-less bearings. Made b **New England Gear Works,** 201 South End Rd., Southington, Conn

For more data circle MD-107, Page 191

High-Temperature Switch

Precise, compact model IHT panel mounted switch is suitabl for high-temperature application It operates dependably over a tem perature range from −50 to 100 F. Switch requires an operatin force from 10 to 20 oz. Pretrave

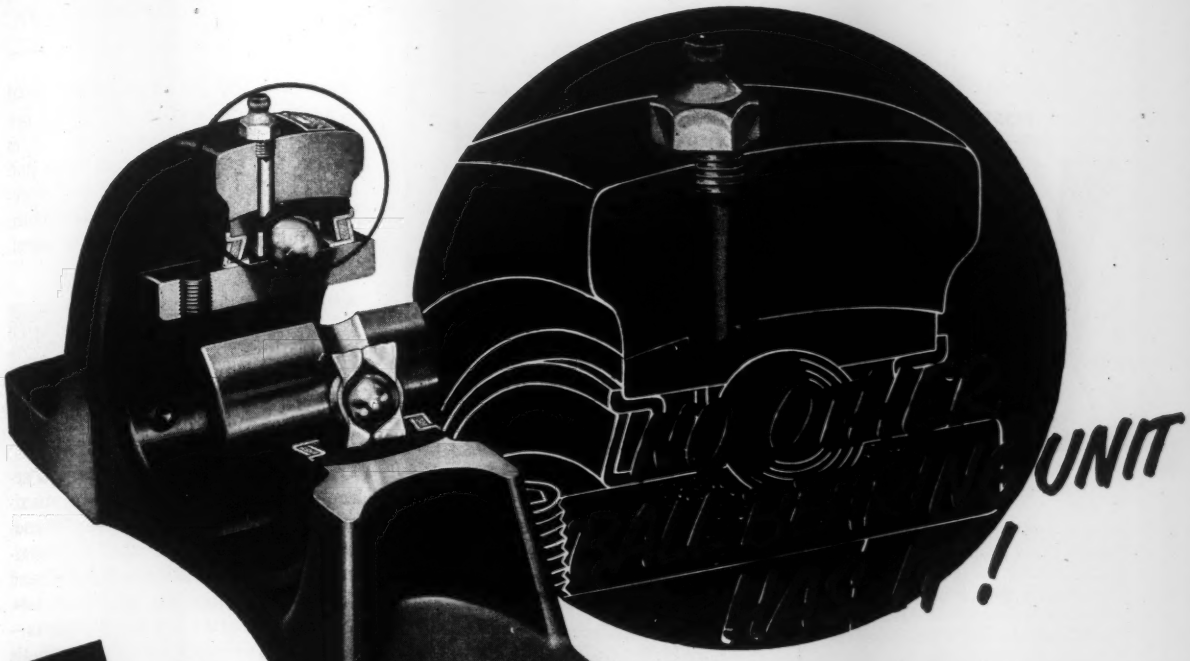


is 0.065-in. maximum; differential travel, 0.010-in. maximum; and overtravel, 0.125-in. Hexagonal locknuts permit adjustment of operating point without removing switch from its mounting. Made by Micro Switch Div., **Minneapolis-Honeywell Regulator Co.,** Freeport, Ill.

For more data circle MD-108, Page 191

Solenoid Valves

Diaphragm - operated solenoid valves, available in ⅜, ½, ¾, 1, 1¼ and 1½-in. pipe sizes, control air; water; oil; refrigerants; natural, manufactured, propane and butane fuel gases and sulphur dioxide gas. They operate on line pressures of ½-in. of water mini-



Write for your copy of SEALMASTER Catalog 454.

SEALMASTER'S

Patented

LOCKING PIN & PERIMETER DIMPLE

SEALMASTER

BALL BEARING UNITS

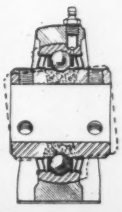
SEALMASTER BEARINGS

A DIVISION OF STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVENUE, AURORA, ILLINOIS

Features like the patented *Locking Pin* and *Perimeter Dimple* have kept SEALMASTER Bearing Units *well ahead* of demands for high speed production in the current trend toward automation. SEALMASTER leadership has set a new standard for low-cost in bearing maintenance and maximum bearing efficiency. It will pay you to consider the advantages of SEALMASTER Bearings in the machines you buy or build.

Rotation of outer race ring in the bearing housing is prevented . . . **eliminating housing wear.**

Locking Pin locates the lubricating hole within the *Dimple* on the outer race ring and has a V-shaped groove at each end to allow a free flow of grease from the grease fitting to the sealed bearing chamber . . . **assuring positive lubrication.**



Locking Pin and *Dimple* allow several degrees of misalignment in any direction. **Misalignment of shaft cannot interfere with the effectiveness of the seal.**

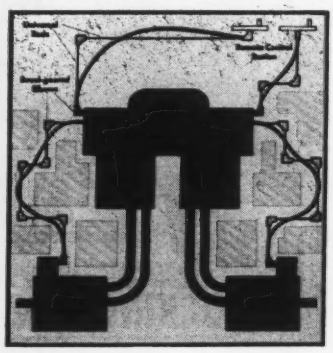
FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

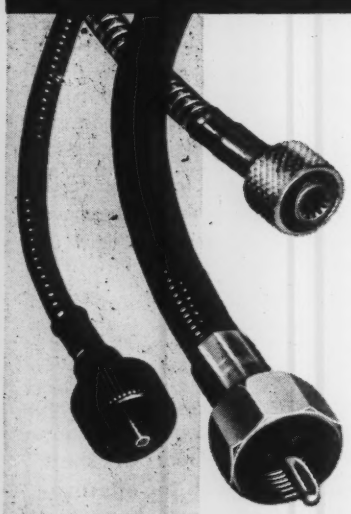
FLANGE UNIT | CARTRIDGE UNIT | TAKE-UP UNIT | FLANGE-CARTRIDGE UNIT

COST-SAVING IDEAS FOR DESIGN ENGINEERS

FOUR
S. S. WHITE FLEXIBLE SHAFTS
REPLACE 35 PARTS
... CUT COSTS 90%

Only 4 S.S.White flexible shafts were needed to control the dual hydraulic system illustrated. They replaced 17 universal rods with their bearings and 18 bevel-geared elbows. The shafts cost only 1/10 as much—they substantially reduced assembly time and labor—eliminated all alignment problems—and provided a degree of sensitivity that was impossible to obtain with the former arrangement. The result: a 100% improved application at a fraction of the original cost!





SAVE TIME, TROUBLE and EXPENSE

When you have a mechanical remote control problem, it's good, sound practice to give first consideration to S.S.White flexible shafts. Their many money-saving advantages offer unlimited opportunities to cut costs and to improve your equipment.

BULLETIN 5306 has basic information and data on flexible shaft application and selection. Send for a free copy. Address Dept. 4.

R-3

THE S.S.White DENTAL MFG. CO. INDUSTRIAL DIVISION
10 East 40th Street
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

New Parts

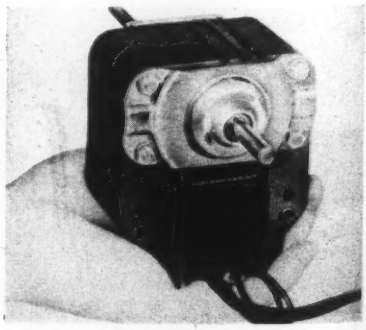
mum and 150 psi maximum. Ideal cycling range is 40 to 60 cycles per minute. Valves have aluminum bodies for gas and air service and brass bodies for oil and water service. Valve seats and armature pilot plungers are stainless steel.

The three smaller sizes are Factory Mutual approved for maximum pressures of 15 psi. Standard coils are rated at 7 w maximum and are available for 115 and 230 v in either 50 or 60 cycles. Valve has two moving parts—solenoid plunger and synthetic rubber diaphragm—and does not employ valve guides, seat ring gaskets, pilot valve-cages, coil retaining screws, washers or springs. All valves are pilot-operated and can be activated by automatic control devices or manual switches. Made by **Eclipse Fuel Engineering Co.**, 1011 Buchanan St., Rockford, Ill.

For more data circle MD-109, Page 191

Shaded-Pole Motor

These small motors, with high starting torques and efficiency, are available in 1/40 to 1/6-hp sizes. Short length and offset shaft make them adaptable to application in small spaces. Basic design is 3000 rpm, 2-pole motor; shaft, mounting studs and fan can be modified to specifications. Applications include use on washing ma-



chines, ironers, centrifugal pumps, fans and blowers, recording apparatus, food mixers, and condensing units. Made by **Northwestern Electric Co.**, 1750 N. Springfield Ave., Chicago 47, Ill.

For more data circle MD-110, Page 191

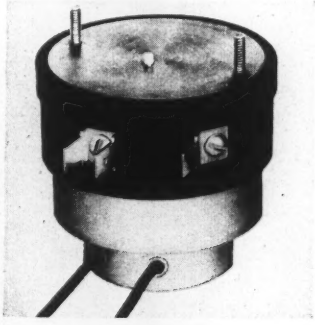
Electrical Tubing

Unaffected by repeated flexing or by heat from soldering irons, this electrical or spaghetti tubing of high dielectric strength Polypenco Teflon can be used for insulating wire conductors, bus leads, subminiature tube pins, etc. It is made in a wide range of sizes in natural white, black, brown, red, green, blue and yellow and in internal diameters from 24 through 8 AWG. It maintains full electrical insulating characteristics, even when fixed or bent. Material is stable at temperatures up to 525 F. Tubing is supplied in 100, 200, 500 and 1000-ft lengths. Made by **Polymer Corp. of Pennsylvania**, 126 N. Fifth St., Reading, Pa.

For more data circle MD-111, Page 191

Fixed Interval Timer

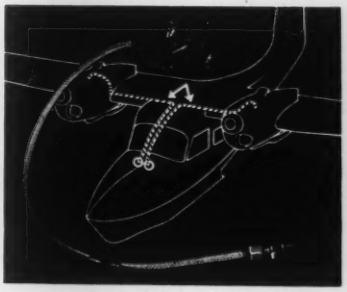
Suitable for operation in any position, series PB fixed interval timer has compact, dust-tight housing. Its Circle B synchronous motor is rated for 25 amp at 115 v, 60 cycles ac. Pushbutton-actuated timer switch turns on the load, then turns it off at the end of the factory-set time interval. Unit is offered with a 15-second to 1-month interval range and has quick-connect terminals, heavy duty solid



COST-SAVING IDEAS FOR DESIGN ENGINEERS

DO IT THE EASY WAY
...USE
S. S. WHITE FLEXIBLE SHAFTS

As shown by the illustration, S.S.White power drive flexible shafts provide completely dependable, trouble-free mechanical connections between wing-mounted aircraft engines and their respective tachometers. No difficulties are experienced in installing the flexible shafts along wing and fuselage contours or around intervening struts and frames.



IT PAYS TO THINK
OF FLEXIBLE SHAFTS

For transmitting rotary power or remote control, S.S.White flexible shafts offer distinct advantages. Why not consider their use on your own applications?

A large selection of sizes and types are available to meet a wide range of requirements.

BULLETIN 5306 gives details on how to select and apply flexible shafts. Send for your copy. Address Dept. 4.

P-3

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
10 East 40th Street
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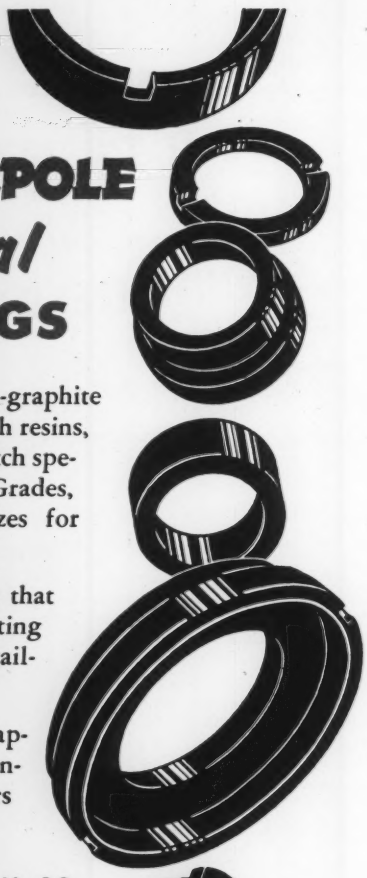

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Seal
RINGS

Molded from carbon-graphite materials balanced with resins, waxes or metals to match specific requirements. Grades, types, shapes and sizes for practically any need.

New Oil Seal Grades that greatly minimize pitting and blistering now available.

Send details of your application for recommendation by our engineers and samples for test.

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St. Marys, Pa.

STACKPOLE

"everything in Carbon but diamonds"

BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT
ELECTRICAL CONTACTS
CHEMICAL CARBONS
TROLLEY and PANTAGRAPH SHOES
CARBON PILES
FRICTION SEGMENTS
RESISTANCE WELDING and BRAZING TIPS

... and many other carbon, graphite and molded powder products

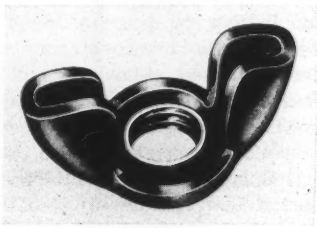
New Parts

silver contacts, nylon cam, latch and operating button. Size is 2¼ diameter x 2⅛ in. Made by Bristol Motor Div., **Vocaline Co. of America Inc.**, Vocaline Bldg., Old Saybrook, Conn.

For more data circle MD-112, Page 191

Stamped Wing-Nuts

Automation techniques used in production of these stamped wing nuts result in substantial unit cost savings. Nuts are available in regular, extra-wide and flat styles in

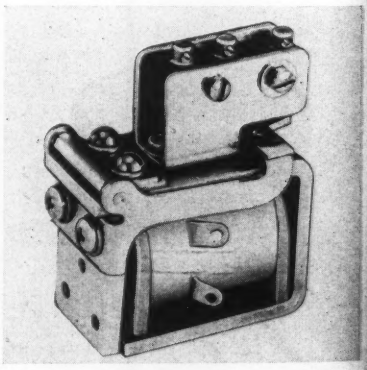


all machine screw sizes, made of steel, brass or aluminum. Manufactured by **Jacobson Mfg. Co.**, Kenilworth 10, N. J.

For more data circle MD-113, Page 191

Plate Circuit Relays

Snap-action contacts provide positive and instantaneous switching action in relays designed for plate circuit use and current and voltage sensing applications. Line includes precision types for high accuracy, identical repeatability, and resistance to shock and vibration; as well as relays for less



want high speed plus endurance? How's this...

1000 HOURS at 3600 R.P.M. UNDER FULL LOAD!

If you were to drive 90,000 miles up an incline at 90 m.p.h., you would approximate the performance of the Model 24A, 331 cubic inch displacement Chrysler Industrial Engine pictured below.

To prove the power of Chrysler Industrial V8 Engines . . . their ability to run for long periods of time at high speed . . . on March 17, 1954 Chrysler engineers placed a production model Ind. 24A Engine on an endurance dynamometer at Chrysler Central Engineering Laboratories. Objective: 1000 hours operation at 3600 R.P.M. under full load.

During every one of the 1000 hours, the Chrysler Ind. 24A Engine delivered an average of 174 horsepower and when shut down, the engine was still in perfect operating condition.

During the run no service was necessary beyond minor maintenance care, such as oil changes and very infrequent spark plug changes and point adjustment. Yet, following disassembly of the engine, the only wear noted was negligible—no more than you might expect from an engine that has been operated for 1000 hours within a long period of time.

While there is every reason to believe that this is a record-breaking endurance run (and don't forget it was made at 3600 R.P.M. under full load), we are confident that every Chrysler Industrial V8 Engine will *at least equal* this astounding record.

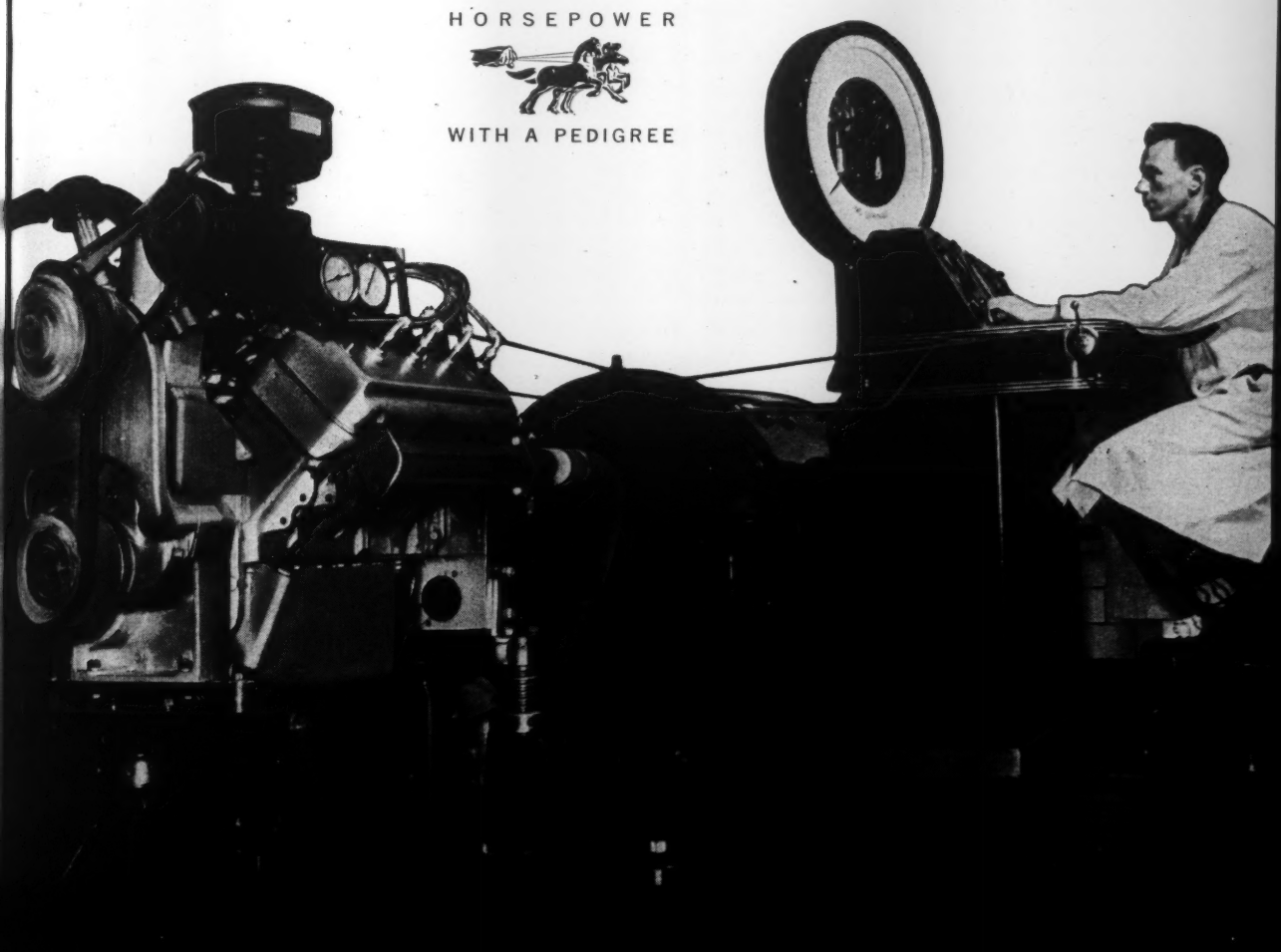
This proves too, beyond a doubt, that the Chrysler Industrial V8 hemispherical combustion chamber design with its short-stroke, low-friction construction, makes an ideal power plant for any equipment that requires continuous high speed operation. Furthermore, in installing a Chrysler V8 Engine in preference to a diesel engine of similar horsepower, you can reduce your size estimate by one-half, your weight by two-thirds, and your cost factor by three-quarters!

For detailed information on the Model 24A or any Chrysler Industrial Engine, see a Chrysler Industrial Engine Dealer, or write: ***Dept. 68, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

CHRYSLER *Industrial Engines*

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

HORSEPOWER WITH A PEDIGREE



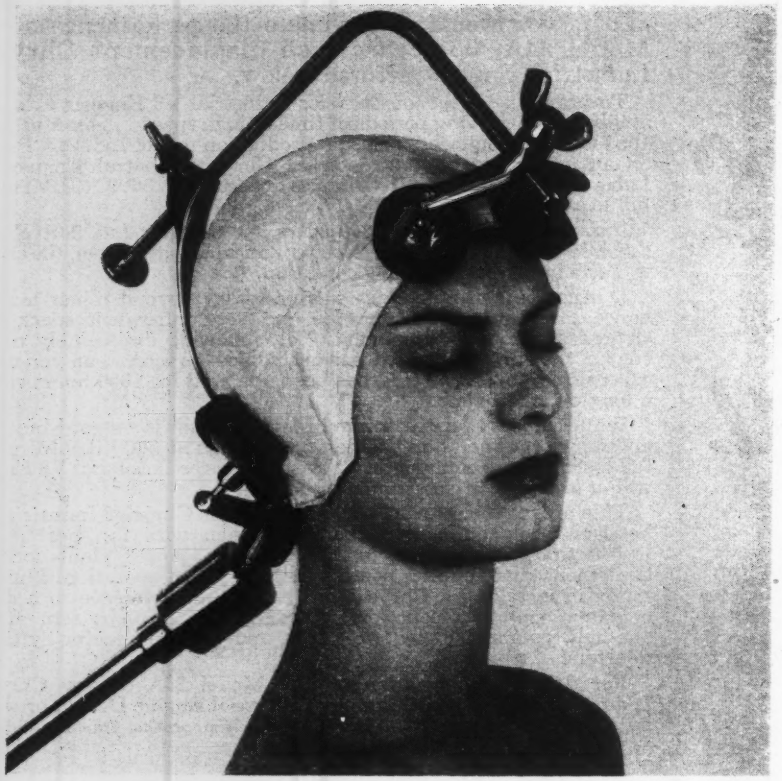


Photo courtesy American Sterilizer Co., Erie, Pa.

"Just What the Doctor Ordered"

New Super-Soft Rubber Pads Developed for Surgical Table Headrest

This surgical patient's head is in firm but gentle hands. The tight grip of the surgical table headrest shown above is now cushioned by super-soft (20 durometer) solid rubber pads. These pads are almost as soft as sponge but can be decontaminated and sterilized far more easily. Being made of neoprene, they are unaffected by oils, acids or decontaminating and sterilizing solutions. Furthermore, repeated sterilizing in live steam does not cause excessive hardening.

The neoprene compound specially developed for this purpose is 10 to 15 durometer points softer than normal commercial limits. For that reason, special care and skill must be taken in mixing and molding.

The successful development of this special purpose rubber part typifies the complete engineering and laboratory—as well as manufacturing—service offered by Continental.

Why not let Continental engineers consult with you in the planning or blueprint stage? Their specialized skill might help you get better rubber parts for your requirements.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these standard parts are shown in Continental's No. 100 Engineering Catalog. Send for a copy today. This catalog also is shown in Sweet's File for Product Designers.

Another achievement in **RUBBER**

engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

New Parts

critical on-off applications. Type RL-516, illustrated, has single-pole, double-throw contacts and 6400 ohm coil; it pulls in at 4 milliamps, drops out at 2 milliamps. Dielectric strength, contact to contact or frame, or coil terminal to frame is 1000 v, coil resistance is up to 18,000 ohms, and sensitivity is as low as 80 milliwatts. Made by **Joseph Pollak Corp.**, 81 Freeport St., Boston 22, Mass.

For more data circle MD-114, Page 191

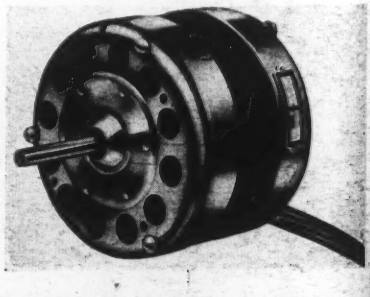
Wipe-On Paint

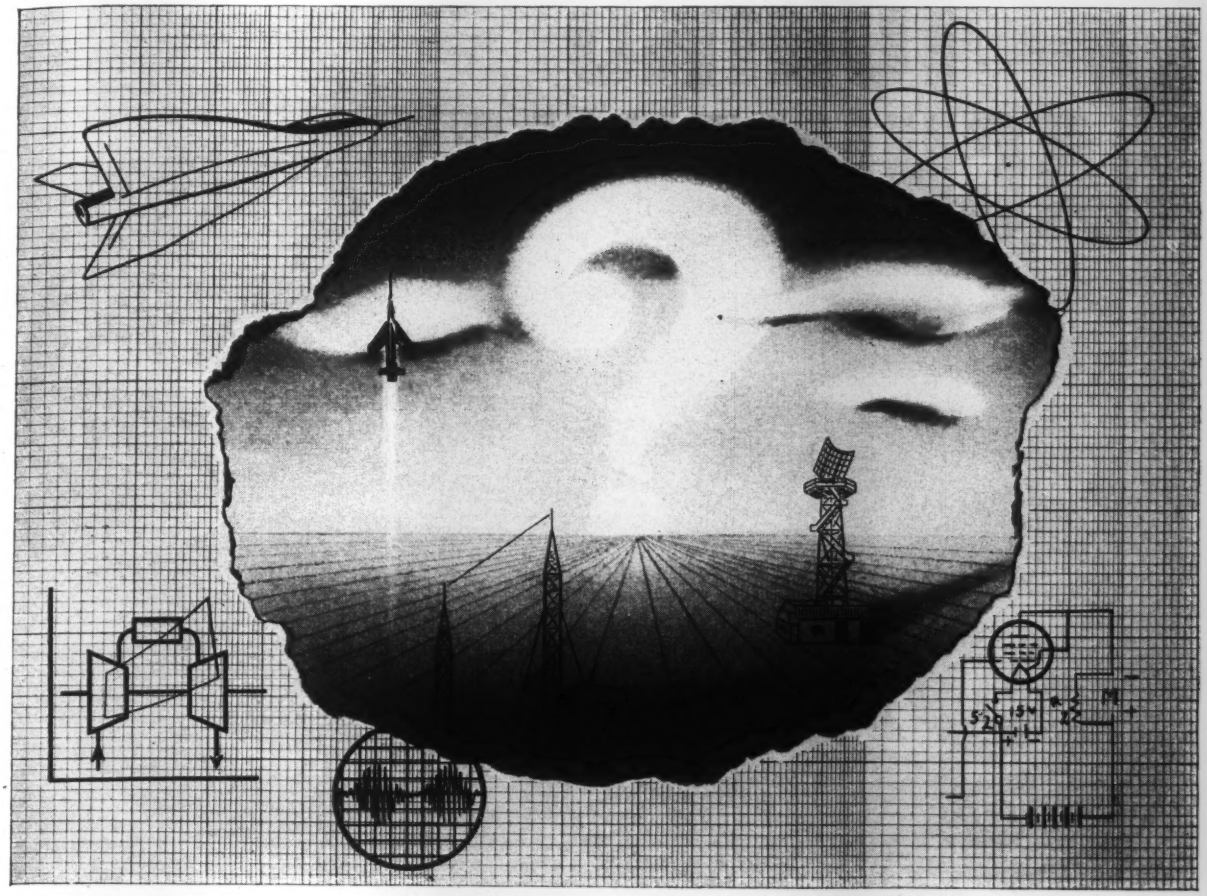
Used to emphasize stamped impressions or engravings on smooth surfaces, Lacquer-Stik is paint in stick form. It hardens permanently, expands and contracts with parts, and withstands temperatures to 500 F. Made in red, blue, yellow, green, silver, gold, white and black, the paint can be applied to metal, glass, ceramics and plastics. Made by **Lake Chemical Co.**, 3052 W. Carroll Ave., Chicago 12, Ill.

For more data circle MD-115, Page 191

Shaded-Pole Motor

Quiet, continuous operation is provided by type 600 six-pole shaded-pole motor. It is available for 115 or 230 v, 60-cycle use, and has no-load speed of 1180 rpm and rated load speed of 1000 to 1050 rpm. It is available with ⅜ or ½-in. diameter shaft, single or double extension and with length or flats to specification. Extra large oil reservoir with felt packing affords long service life to sintered bronze, self-aligning bearings. Power range for continuous fan duty is 1/40 to ⅛-hp; for con-





When products are undefined but performance can be specified

. . . the Special Products Division of I-T-E may be helpful.

We don't claim to solve all development problems to meet performance specifications, but we may have the answer you're looking for. Our record in helping with unusual and advanced developments is impressive. Our current projects range from design, development and fabrication of Radar Antenna Systems to equipment to operate on advanced Thermodynamic theories. Whether your problem is new development – or fabrication with new and hard-to-work alloys – you'll want to know how this unique organization can help you.

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design, development and fabrication of equipment to operate on advanced theories

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advanced fabricating techniques

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proven welding, forging, forming, spinning techniques with this hard-to-work metal

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combining spinning and drawing to an almost limitless variety of designs in a wide range of metals

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TECHNOLOGY
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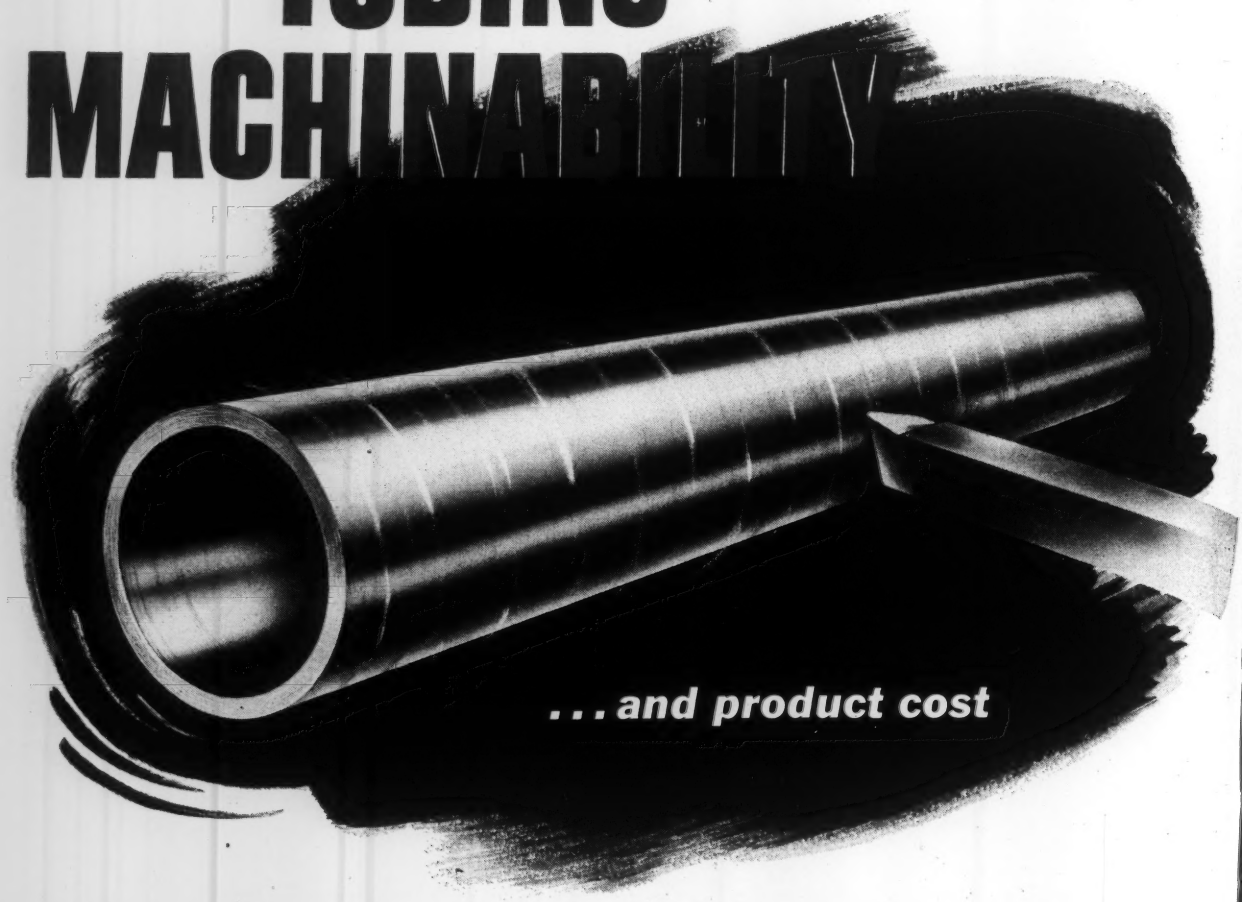
SPECIAL PRODUCTS DIVISION
I-T-E CIRCUIT BREAKER COMPANY
601 E. Erie Avenue • Philadelphia 34, Pa.
Progress through Problem Solutions

TUBING MACHINABILITY



Machinability of tubing is vitally important to producers of hollow cylindrical parts. But in the last analysis, final production *cost* is the real determining factor. Consequently, choosing the mechanical tubing that will easily machine to the quality finished part you demand and also hold final cost to the minimum, requires careful consideration of all the factors involved.

Matching the tubing to your own product needs and production equipment is important. Getting — in the tube — as many as possible of the characteristics and properties desired in the finished part, is equally important. Finish, heat treatment, tolerances, steel quality, alloy factor—any or all of these can be supplied within the original B&W mechanical tubing, to either eliminate or to reduce your machining and other production operations.

Because B&W mechanical tubing is tailor-made to suit your combination of production conditions and product specifications, you win on all counts. You'll find that the machining characteristics of the B&W tubing you select make it particularly suitable for your type of machine tool. Since you start with the desired properties, your production time and costs are pared to the bone.

B&W Regional Sales Offices, together with a nationwide network of B&W Distributors, are always prepared to serve you. You'll find Mr. Tubes — your link to B&W—always available to provide unbiased assistance in meeting your specific mechanical tubing requirements.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.— Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio — Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-4025(M)

tinuous mechanical duty, from 1/50 to 1/15-hp. Made by **Lloyd Scruggs Co.**, Festus, Mo.

For more data circle MD-116, Page 191

Rotary Plate Valves

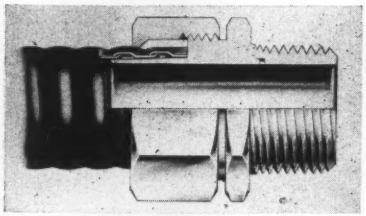
Series of hydraulic noninterflow rotary plate valves are available for use in 1500 and 3000 psi systems. Design, which incorporates

two optically true hardened steel plates, virtually eliminates leakage between ports. Valves are housed in an aluminum alloy body. Made by Pacific Div., **Bendix Aviation Corp.**, 11600 Sherman Way, North Hollywood, Calif.

For more data circle MD-117, Page 191

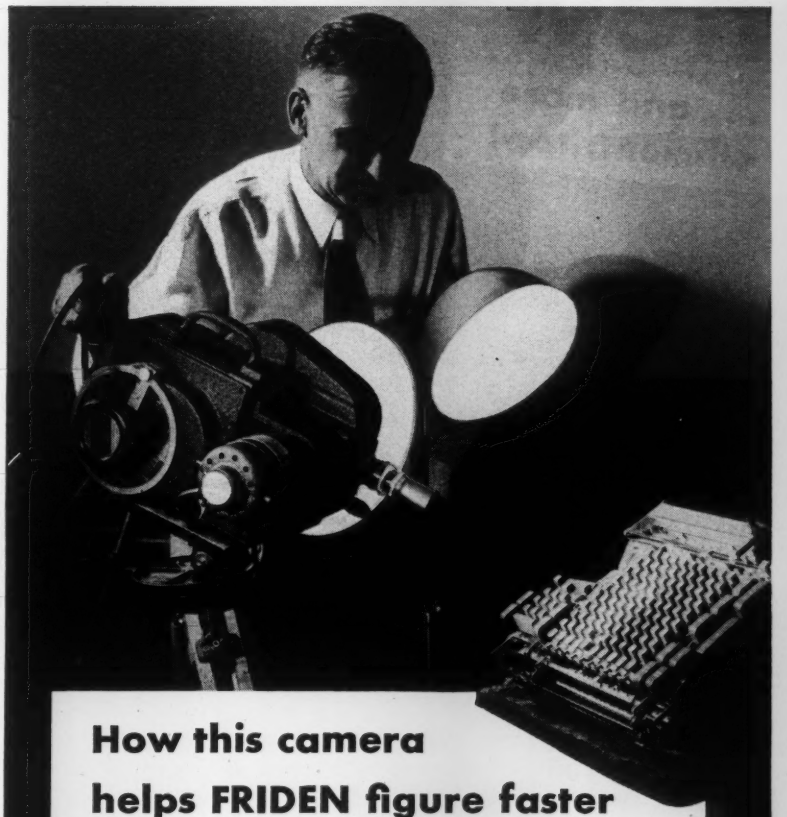
Conduit Fitting

Series CT liquid-tight connector is available in straight, 45-deg and 90-deg types for 3/8 to 2-in. flexible conduit. Compression force is supported by the body shank as well



as the conduit. Gripping is well behind the end of the flexible conduit for firm anchorage against creeping. The pliable seamless sleeve makes a plastic-to-plastic

(*Continued on Page* 244)



How this camera helps FRIDEN figure faster

FRIDEN Calculating Machine Co., Inc., has a calculator that extracts square roots to ten decimal places almost instantaneously. The parts move just as fast as you would imagine.

Friden engineers *thought* part 461B was causing miscalculations in an experimental model of this machine. High speed movies, taken with a Kodak High Speed Camera, *showed* otherwise. Projecting the film at less than normal speed slowed action as much as 300 times. At this speed, they could *see* that a nearby part brushing against others was the culprit.

Not only does this camera show *what* happens, but it can also a) put a timing signal on the film and b) actuate an external circuit at any desired instant during the couple of seconds of operation being studied.

Hundreds of manufacturers of products ranging from sugar beet harvesters to cigarette lighters are using Kodak High Speed Cameras to help solve their product design and performance problems. You may have one that high speed movies can make short shrift of. To find out more, write for a copy of "High Speed Motion Picture Making in Industry."

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

the Kodak *HIGH SPEED* camera

Kodak

new

. . . and more efficient, too!

• Custom-designed for regular pro tion!

• Built for a lifetime of service!

LELAND LOADSTAR MOTO

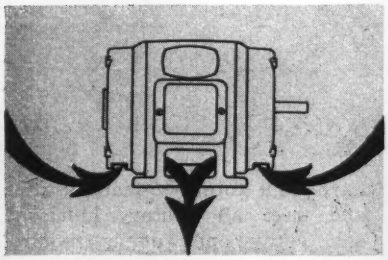
A completely new line of motors!

more power-packed . . . *higher in efficiency* . . . lighter in weight . . . smaller . . . better protected . . . quieter running . . . more efficiently cooled . . . more flexible . . . easier to install . . . modern in appearance . . . and maintenance-free!

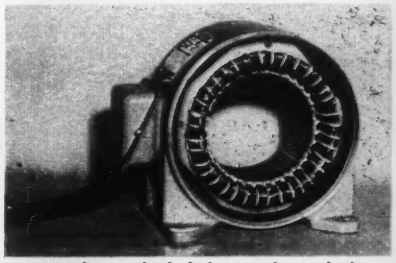
COMPARE this new polyphase, dripproof LELAND *"Loadstar"* motor point by point, feature by feature—the way we do at the factory—with all leading makes of motors! See if you, too, don't find it even further ahead of competition than previous LELAND motors, prior to rerating!

Users of LELAND motors have been enjoying outstanding performance, extra capacity and greater durability for a long time . . . perhaps unaware that these characteristics were often due to LELAND's advance use of improved electrical steels and high-dielectric insulating materials, which have *made possible* the new NEMA ratings!

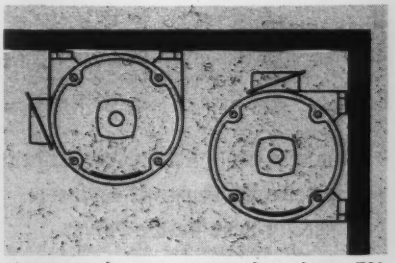
This completely new line of *"Loadstar"* motors carries over, with added refinements, many time-proved LELAND features. Others, entirely new, reflect LELAND's unique experience and creative engineering. Some of these are shown below. For the complete story and frame dimension details, *write for Bulletin No. 103.*



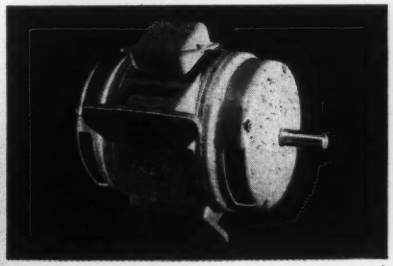
Cooling: (by convection) dual fans draw air in both ends, discharge through center vents; (by conduction) through partial stator-core-to-outer-shell contact, shown in cut at right.



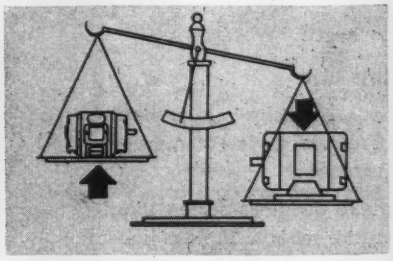
Leland's denser, high-dielectric slot and phase insulation takes less room, permits more copper in each slot, increases efficiency and aids heat transfer.



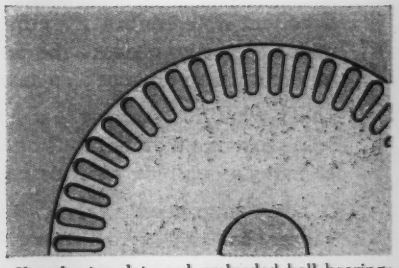
End shields have openings only in lower 70° . . . can be rotated for dripproof mounting on wall or ceiling. Drip cover provides for vertical dripproof mounting.



Rigid cast iron center and end frames (painted gray) assure accurate rotor alignment.



New motors take up to 40% less space; save as much as 33% in shipping weight.



Closed rotor slots and preloaded ball bearings eliminate whir and rattle heard in many motors.

New "Loadstar" polyphase, dripproof motors in 1, 1½ and 2 HP (180 frames) now ready. Totally enclosed and explosion-proof frames—also higher horsepower and single phase motors—available soon.

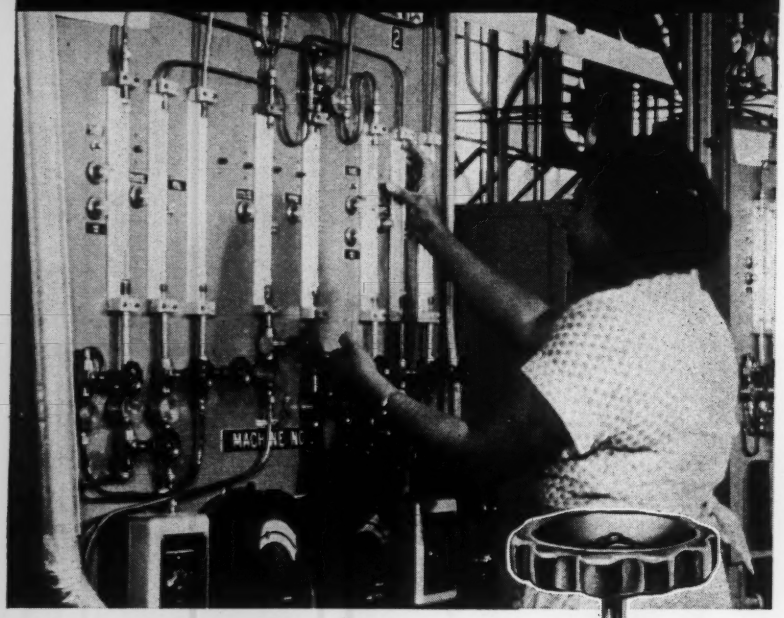
Another AMF Product

LELAND MOTORS

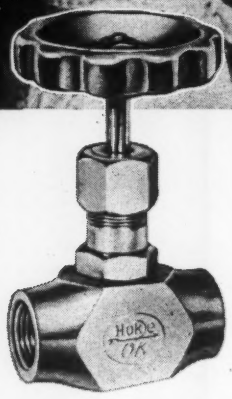
LELAND motors in previous NEMA standard frames will continue to be available for replacement and the convenience of present customers.

THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO, *Division of American Machine & Foundry Company*

HOW TO MAKE PRECISION RESISTORS WITH NEEDLE VALVES



International Resistance Company process development engineers specify Hoke Needle Valves for precision control in Boron-Carbon resistor production



Excellent flow control...ability to meter corrosive gases...rugged... minimum maintenance...reasonable cost.

That's what IRC engineers say about the Hoke valves they're using to make their Boron-Carbon Precistors, vital components of today's complex electronic equipment.

In addition to needle valves, we make packless styles, toggle valves, bar stock types—just about the most complete line of small valves available. We'd like to help with your valve problems.

Write for complete information.

HOKE

HOKE INCORPORATED

Fluid Control Specialists

191 S. DEAN STREET, ENGLEWOOD, N. J.

New Parts

(*Continued from Page* 241)

grip with the conduit sheath. Ground connection permits less than 10 mv drop. Tapered grounding shank which is integral with connector body makes a contact wedge with the flexible metal conduit. Connectors, which can be installed assembled, meet Underwriters' and J.I.C. standards. Made by **Pyle-National Co.**, 1334 N. Kostner Ave., Chicago 51, Ill.

For more data circle MD-118, Page 191

Servo Motors

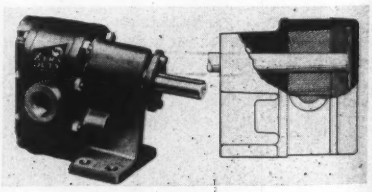
Designed for operation in regions of 320 F, line of servo motors is available with a wide choice of plain or pinion shafts. Motors

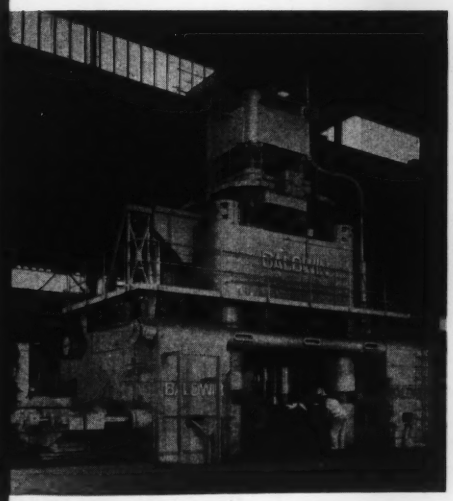
have high torque-to-inertia ratios and meet all military humidity, salt spray and fungus requirements. Made by **American Electronic Mfg. Inc.**, 9503 W. Jefferson Blvd., Culver City, Calif.

For more data circle MD-119, Page 191

Tapered Gear Pump

Liquids containing materials of an abrasive nature or foreign matter can be handled efficiently by the model U-3 tapered gear pump. Initial mechanical and volumetric efficiency are maintained, since taper design automatically takes up any wear without effect on clear-





These propeller blanks were forged on Cameron's 26,000 ton multiple ram split-die ferrous metal forging press.

ANOTHER LARGE SIZE AND INTRICATE SHAPE IS FORGED

Pictured above are 64" aircraft propeller blanks now being forged from steel, rough machined and cold pressed at Cameron Iron Works, Houston. These forgings, free of inclusions and crevices, are then drawn and shaped by the prime contractor into propeller blades.

You too may have the need for forgings which will result in improved quality products at lower manufacturing costs.

FORGE AND ORDNANCE DIVISION

Cameron

IRON WORKS, INC.
HOUSTON, TEXAS

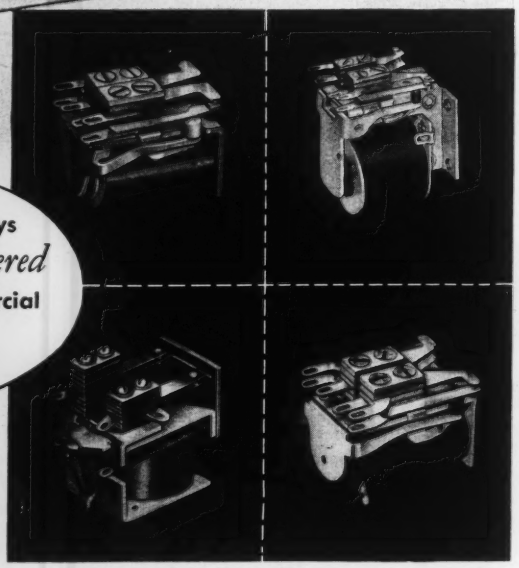
Write today for further information.

for efficiency...
for dependability...

COMAR RELAYS

are your best buy

Comar Relays, "tailor-made" to fit the job, are easier to install, more efficient, more dependable. You get the EXACT electrical characteristics and physical size you want...you get custom quality ...yet you pay no more.



Top Quality Relays
Custom-Engineered
For Use in Commercial and Military Apparatus

Aircraft Controls
Business Machines
Radar Systems
Electric Cameras
Guided Missiles
Communications
Transcribers
Coin Machines
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Alarm Systems
Computors
Test Panels
Electric Timers
Tape Recorders
Electric Toys
—hundreds of others

Our Engineers Will Help You

We invite you to submit your relay problems and specifications for our recommendations. No cost or obligation.

Comar ELECTRIC COMPANY
3349 ADDISON STREET
CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING

New Parts

ances. Unit attains a 29-in. vacuum level under conditions of restricted flow. With a normal capacity of 8 gpm, pump will deliver up to 18 gal at 1000 rpm shaft speed, at pressures up to 250 psi. Made by **East Shore Machine Products Co.**, 50 E. 201st St., Cleveland 23, O.

For more data circle MD-120, Page 191

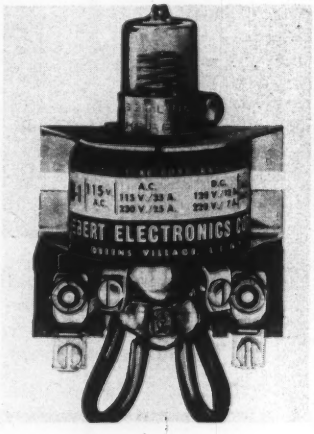
Adhesive Sealer

Nondrying, nonhardening No. 576.1 Permagum is a white mastic sealer extruded in beads from ⅛-in. in diameter and tapes from 1/16-in. thick and ½-in. wide. Sealer can be painted over immediately after application. It will not flow or run at 350 F, will not harden at 200 F, is unaffected by paint baking temperatures and will not become brittle or lose adhesion at −20 F. Made by **Presstite Engineering Co.**, 3798 Chouteau Ave., St. Louis 10, Mo.

For more data circle MD-121, Page 191

Mercury Plunger Relays

Mercury cup of improved mercury plunger relay is made of alumina, which has high flexural strength. Bakelite blocks facilitate installation, and Burndy connectors can be set in either of two directions for load line connection. Relay is hermetically sealed in glass tube for operation in explosive atmospheres. Normally



if you want lower V-Belt costs—

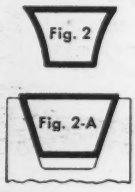
When a V-Belt bends, you can feel its sides change shape.

just make this simple test

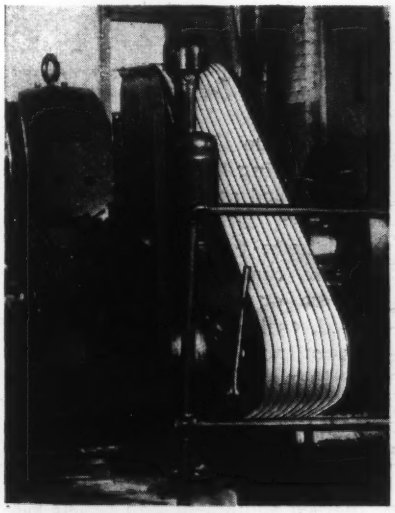
Take *any* V-belt that has *straight* sides (Fig. 1). Bend that V-belt while you grip its sides with your fingers. You will *feel* the sides *bulge out* (Fig. 1-A). Clearly, that out-bulge forces the belt to press *unevenly* against the V-pulley—and this *concentrates* wear at the points shown by arrows (Fig. 1-A).

Now bend a Gates Vulco Rope with CONCAVE SIDES (Fig. 2)

(U.S. PAT. NO. 1813698)



Instead of *bulging,* the precisely engineered CONCAVE SIDES merely *fill out* and become perfectly straight. This belt, when bent, *precisely fits* its sheave groove (Fig. 2-A). The sides of the Gates Vulco Rope press *evenly* against the V-pulley. Therefore, wear is distributed *uniformly* across the *full face* of this belt —resulting in *longer* belt life and *lower* belt *costs* for you!



Typical Gates Vulco Rope Drive —the Gates V-Belts are built with Concave Sides to insure longer belt wear.

When you buy V-belts, be sure to get the V-belt with the Concave Sides—the Gates Vulco Rope!

Gates VULCO ROPE DRIVES

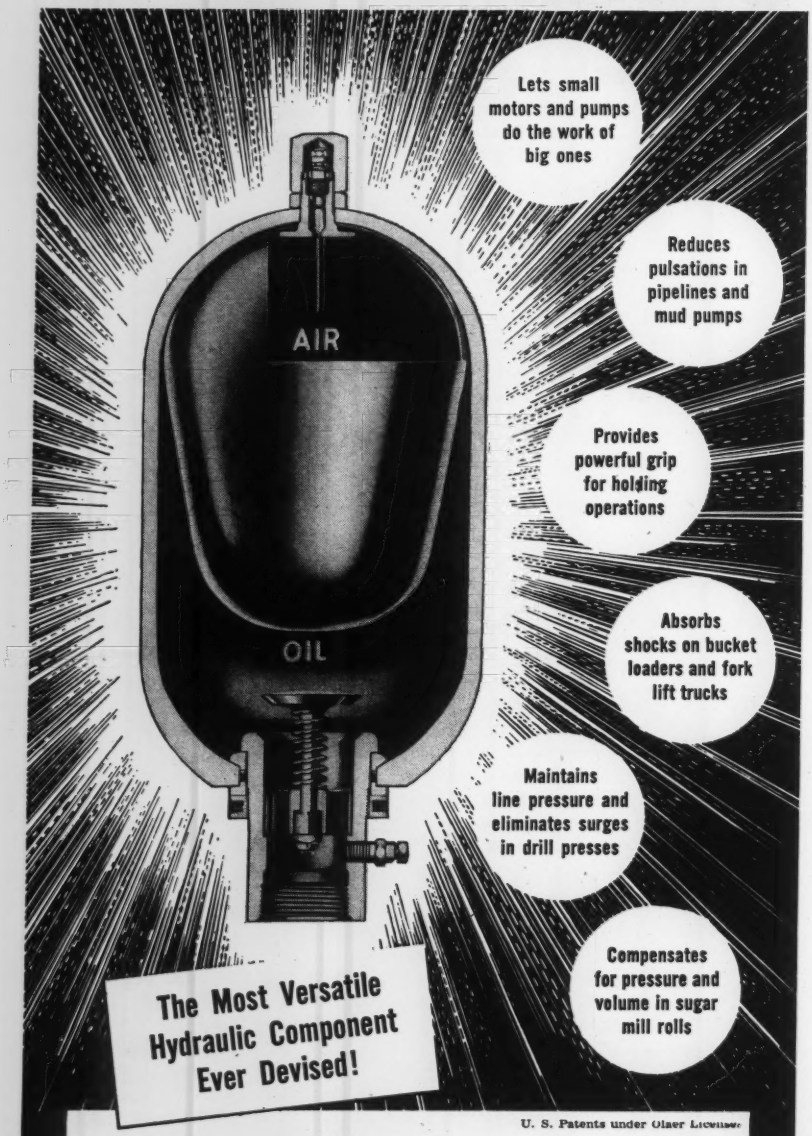
REG. U. S. PAT. OFF.

Gates Engineering Offices and Jobber Stocks are located in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

THE GATES RUBBER COMPANY
DENVER, U.S.A.

CS-543

THE GREER ACCUMULATOR



U. S. Patents under Olaer Licenses

Today, Greer Accumulators are found in every conceivable hydraulic circuit — the few applications mentioned above show tremendous diversity of use. Their wide acceptance is due to these important reasons. 1) simple operation, 2) ease of installation, 3) minimum maintenance, 4) *and complete safety*. They are rugged and dependable, too — each built to take many times the expected work load.

Let our experienced application engineers show you how a Greer Accumulator can reduce the cost, size, weight and complexity of your hydraulic equipment. Our Brochure 301-A gives you technical data on the Greer Accumulator. Write or call today for your free copy. No obligation.

GREER HYDRAULICS INC. • International Airport • JAMAICA 30, NEW YORK

Field offices in Chicago, Dayton and Detroit • Sales Representatives in all principal cities

New Parts

open EM-1 unit illustrated is rated 35 amp at 115 v ac and 25 amp at 230 v ac. Normally open heavy duty HD-1 relay is rated 60 amp at 115 v ac and 35 amp at 230 v ac. Horsepower ratings are 2 hp at 115 and 230 v ac and ½-hp at 120 and 220 v dc. Normally closed contacts are available. Made by **Ebert Electronics Corp.,** 212-26 Jamaica Ave., Queens Village 28, L. I., N. Y.

For more data circle MD-122, Page 191

Paper-Base Laminates

Series 300 paper-base hot-punch laminates are uniform throughout the sheet, with no surface overlay of resin. They offer a variety of electrical and physical properties and have good punching and staking characteristics. Four types are available, ranging from XXXP-301, a high grade laminate with low power factor, high insulation resistance and low water absorption, to Grade 353, a low-priced, easily fabricated material with good stability and low water absorption. All are available in sheets to 49 x 49 in. Made by **Taylor Fibre Co.,** Norristown, Pa.

For more data circle MD-123, Page 191

Protective Coating

Neoprene Magic - Vulc protective coating 245-B can be sprayed or brushed on metal, wood, plastic or other surfaces and imparts high resistance to corrosive attacks of water, fumes or other chemicals. Single or multiple coats can be used, each coat drying in about 2 hours and being from 0.005 to 0.010-in. thick. Coating is tough and elastic, is available in black, aluminum or other colors and has good dielectric qualities. It can be applied successfully to totally immersed equipment and resists sunlight, weathering and seawater. In addition to use for protecting steel, it can be applied as a sealing compound. Made by **Magic Chemical Co.,** 121 Crescent St., Brockton 2, Mass.

For more data circle MD-124, Page 191

weight lifters aren't always available

KEEP YOUR PRODUCT

Lightweight!

Power Products new industrial engine offers

60% *less engine weight*

42% *less engine size*

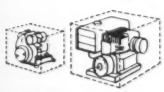
NOW you can give your power equipment the Lightweight being demanded by all of industry. Power Products engines are not just a little lighter—they're 60% lighter than any currently available industrial engine of comparable horsepower . . . and that means greater portability for equipment. Wheels, carriages, etc., formerly necessary for portability, can be eliminated in many cases, allowing further streamlining and extra weight and cost savings.

Power Products engines are more compact in design — easy starting — offer sustained performance at high speeds and are easier to service than any other industrial engines. Yet they actually cost less!

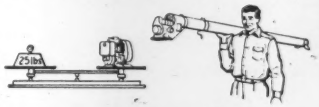
If you want better acceptance — better performance for any industrial product that requires from 2 to 4 horsepower . . . switch to Power Products Lightweight!

LOOK AT THESE FEATURES

Lightweight — A standard 3½ H. P. industrial engine weighs as much as two and one half Power Products industrial engines of 3½ H. P.



Compact—A unique design makes this engine amazingly compact. A comparison of overall dimensions shows a saving of 72% in size over the standard engine.



LOOK AT THE RESULTS—"Pump and motor weigh only 25 lbs.," reports a leading pump manufacturer. This is typical of the kind of amazing lightweight products these engines make possible.

"Only 41 lbs., and usable anywhere, at any angle." Grain auger manufacturers are among the many who have found it possible to revolutionize their products with these engines.

POWER PRODUCTS CORPORATION

2018 N. 12th Street Grafton, Wisconsin

Gentlemen:

I know what important advantages weight saving can give my products. Please send me full information on these new engines.

Name.....

Company.....

Address.....State.....

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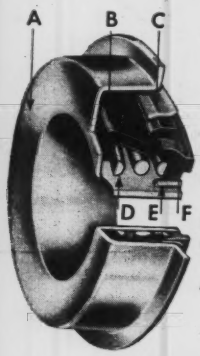
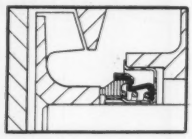
3 REASONS WHY DESIGN ENGINEERS PREFER THESE THREE JOHN CRANE "PRESSED-IN" SEALS

- ✓ Quickly Installed
- ✓ Extremely Compact
- ✓ Low in Cost

STATIONARY SEALING HEAD TYPE 11-A



A. Seal Retainer.
B. Synthethic Rubber Bellows.
C. Metal Band.
D. Spring.
E. Holding Dents.
F. Precision-Lapped Sealing Washer.



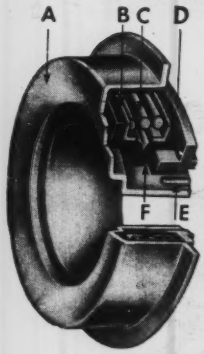
This pressed-in packaged sealing unit is designed with the spiral steel spring inside of the synthetic rubber bellows to protect it against corrosion.

The spring clamps the flange of the bellows tight against the bottom of retainer and the metal ferrule squeezes the top portion of the bellows against the "Teeplelite" washer.

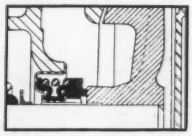
This liquid-tight seal is especially recommended for small shafts on *hot or cold water, oil, gasoline, kerosene, soapy water.*

Use this seal on: *Low Pressures* to 35 PSI
Temperatures —65°F. to +220°F.

STATIONARY SEALING HEAD TYPE 6-A



A. Seal Retainer.
B. Metal Ferrules.
C. Spring.
D. Precision-Lapped Sealing Washer.
E. Holding Dents.
F. Synthetic Rubber Bellows.

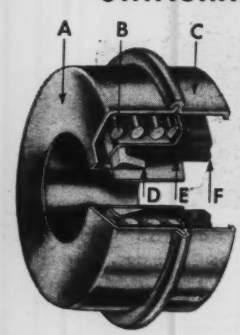


This pressed-in packaged sealing unit is designed with a spiral steel cadmium plated spring (stainless or bronze optional) assembled between two metal ferrules which clamp the flanges of the synthetic rubber bellows tightly against the retainer shell and the "Teeplelite" washer.

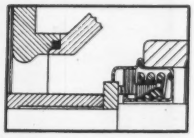
This liquid-tight seal is especially recommended for small shafts on *hot or cold water, oil, gasoline, kerosene, soapy water.*

Use this seal on: *Medium Pressures* to 75 PSI
Temperatures —65°F. to +220°F.

STATIONARY SEALING HEAD TYPE 9-A



A. Seal Retainer.
B. Spring.
C. Sleeve.
D. Wedge of Teflon.
E. Sealing Washer.
F. Precison-Lapped Face.



This pressed-in packaged sealing unit is designed to use a wedge sealing ring of Teflon*. This wedge shaped sealing ring closely fits the inner sleeve of the retainer and makes a liquid-tight contact with cone surface of carbon washer.

The result is a liquid-tight seal which is especially recommended for *hot oil, and all chemical liquids or gases, hot or cold.*

Use this seal on: *High Pressures* to 150 PSI
High Temperatures +485°F. *Low Temperatures* —120°F.

Write for fact-filled catalog. Crane Packing Company, 1825 Cuyler Ave., Chicago 13, Ill.
In Canada: Crane Packing Company, Ltd., 617 Parkdale Ave., N., Hamilton, Ont.

*DuPont trademark

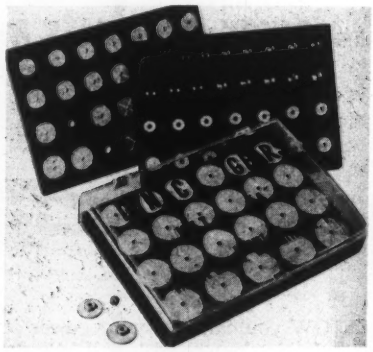
JOHN CRANE
CRANE PACKING COMPANY

ENGINEERING DEPARTMENT

EQUIPMENT

Gear Kits

Developed to provide a solution to gear train problems, Dynaco kits of precision stock gears are available in three different sizes. Consisting of 82 gears, kit A has every tooth number from 20 through 100, plus an additional 1-in. pitch diameter gear. Kit B contains the 34 most commonly used gears, plus every prime number of teeth from 20 through 100.

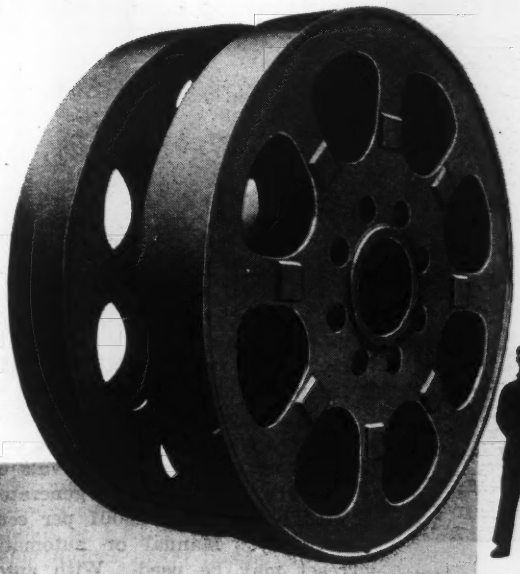


Kit C contains 15 gears, making possible the development of 195 commonly used ratios. Diametral pitch sizes of 48, 64, 72 and 80 and pressure angles of 14½ and 20 deg are available in all selections. Made by **Dynamic Gear Co. Inc.**, Amityville, N. Y.

For more data circle MD-125, Page 191

Preset Interval Generator

Model 564 preset interval generator is designed for testing and calibrating systems that rely on precise time measurements for their operation. Time intervals and delays from 1 microsecond to 1 second may be generated or measured. Unit is a megacycle predetermined counter with a built-in time-base oscillator that



When you need LARGE—HEAVY and ACCURATE Weldments

call on

STRUTHERS WELLS

Twin Turbine Gear Wheel for Westinghouse Electric Corporation

Of heavy steel throughout with a hollow bored steel hub made in our own forge plant.

Column Bearing Plates for Loewy-Hydropress, Incorporated, N.Y.C.

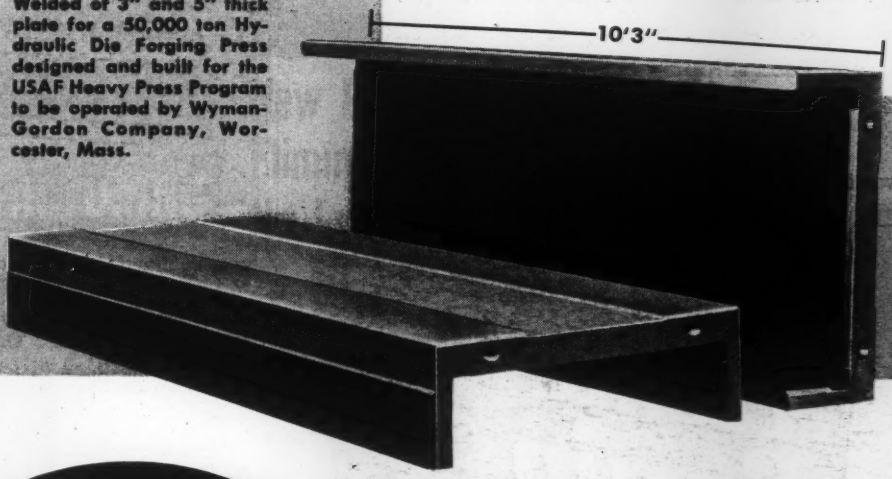
Welded of 3" and 5" thick plate for a 50,000 ton Hydraulic Die Forging Press designed and built for the USAF Heavy Press Program to be operated by Wyman-Gordon Company, Worcester, Mass.

The Gear Wheel and Bearing Plates illustrated typify Struthers Wells' manufacturing versatility.

The extensive facilities of three modern plants plus a century of experience are at your service.

We welcome the opportunity of furnishing either the complete assembly or any weldment part that is beyond your capacity.

Write for Weldments bulletin.



Forty of these 8900 lb. bearing plates were supplied for the 50,000 ton Hydraulic Die Forging Press. Dimensions were 45" wide x 15" high x 10'3" long.

Struthers Wells

STRUTHERS WELLS CORPORATION

Titusville, Pennsylvania

Plants at Titusville, Pa. and Warren, Pa.

No. 6 - Precision Operations in the Manufacture of ACME Chains

Rigid inspection of all Acme Chains is a guarantee that every foot of chain you receive leaves our plant in perfect mechanical condition.

Complete
Production Facilities
FOR QUICK SERVICE

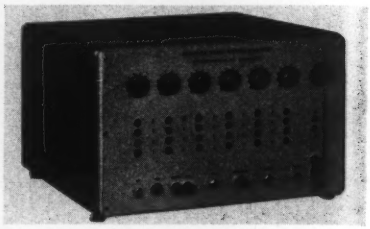
The ACME Organization was built to give prompt and immediate service. The flexibility of our equipment, the crew of skilled mechanics, our large inventory of standard sizes of ACME Chains, and good shipping facilities, all go to give you ACME Chains when you want them — where you want them.

When you want Roller Chains in a hurry, phone Holyoke 2-9458 and we'll do all we can to help you.

Write *Dept. 6L for new illustrated 76 page catalog on use and application of roller chains and sprockets.*

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

Engineering Equipment

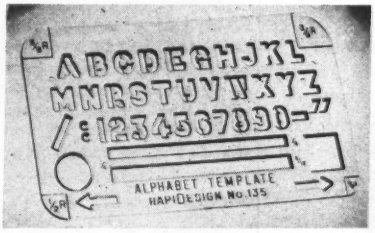


uses a temperature controlled 1-megacycle crystal for long-term frequency stability. Indication is by means of neon lamps arranged to give six-digit readings directly in microseconds. Intervals of the order of seconds are generated with better than 0.0001 per cent accuracy. Manual or automatic reset may be used. With automatic resetting, the instrument recycles itself to produce trains of accurately spaced pulses. Made by **Potter Instrument Co. Inc.**, 115 Cutter Mill Rd., Great Neck, N. Y.

For more data circle MD-126, Page 191

Alphabet Template

No. 135 template has alphabet and numbers for making block letters ⅜-in. high. It also has ⅛, ¼ and 3/16-in. slots for guidance in free-hand lettering. Corners



are rounded to produce radii of ¼, ½, ¾ and 1 in. Template measures 6¾ x 3¾ in. Made by **Rapidesign Inc.**, P. O. Box 592, Glendale, Calif.

For more data circle MD-127, Page 191

Drafting Machine Tray

Pencils, drawing instruments and other drafting equipment can be held in a plastic tray designed to fit the arms of Vemco or other

DESIGN and PRODUCTION NEWS

FOR DESIGN AND MATERIALS ENGINEERS

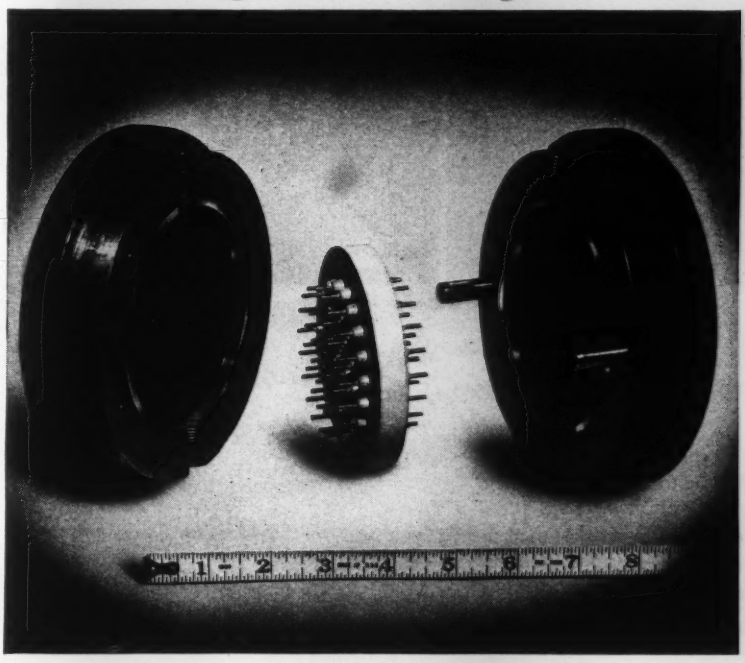
Published by TECHNICAL SERVICE, Chemical Manufacturing Division, The M. W. KELLOGG Company SEPT. 1954

Casting Molds of KEL-F® Polymer Replace Plated Metal Molds... Cut Costs, Finishing and Rejects!

Complex electrical terminal boards, made of an especially abrasive epoxy compound, are now cast in molds of KEL-F polymer, replacing former metal molds. Advantages include lower original mold costs, lower maintenance costs, fewer rejects and higher product precision without extensive machining.

Excellent wear characteristics of the new molds result in longer mold life despite high silica content of the casting resin. The non-hesive properties of KEL-F polymer prevent pitting by the resin, result in damage-free release of the product without special coatings. Penn-Plastics Manufacturing Company, Glenside, Pa., produce these intricate new molds by transfer methods from KEL-F polymer Grade 300.

For further information ask for Application Report P-101



For complete information regarding any item mentioned in DESIGN AND PRODUCTION NEWS, ask for detailed APPLICATION REPORTS, write

CHEMICAL MANUFACTURING DIVISION

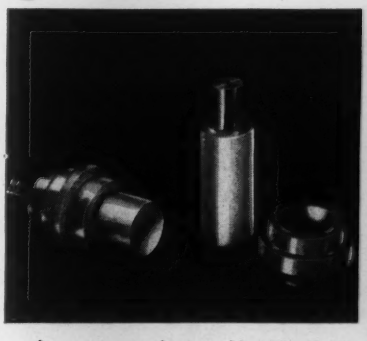
M. W. KELLOGG

KELLOGG PULLMAN

New Bearings of KEL-F® Polymer Eliminate Shaft Seizing... Need No Lubrication!

Shaft seizing is stopped and lubrication is eliminated when rotating metal plating racks are equipped with end bearings of KEL-F polymer. Chemically inert, the tough plastic bearings are unaffected by the most corrosive cleaning and plating solutions...allow smooth rotation. Bearing "drag" is low because the fluorocarbon is dimensionally stable. It will not swell or shrink in contact with water, steam or chemical vapors.

Kurz-Kasch, Inc., plastic molders of Dayton, Ohio, compression-mold the two-piece bearings from KEL-F polymer Grade 300 for use in plating equipment manufactured by The Stolle Corporation, Cincinnati, Ohio.



For further information ask for Application Report C-117

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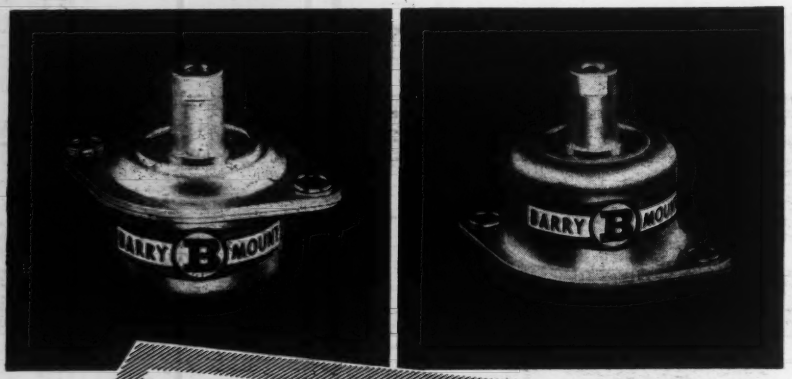
the **NEW** *miniature*

...ALL-METL

BARRY B MOUNT

UNITS SHOWN ACTUAL SIZE



for all-temperature vibration protection of airborne equipment

These new isolators are
the latest addition to the famous
Barry ALL-METL line.
They are specifically designed to help you meet miniaturization demands under toughest environmental conditions.

Temperature range — from −60°C to +175°C
Weight — only ½ ounce per unit isolator
Height — only 1¼ " free, 25/32" bottomed
Load ratings — 0.1 to 3.0 lbs. per unit isolator
Performance — meet all relevant requirements of JAN-C-172A/MIL-C-172B
Ruggedized — to meet shock tests under specifications AN-E-19, MIL-E-5272, MIL-T-5422B, and MIL-C-172B.
Mounting styles — available in plate and cup types, as illustrated, for 2-hole or 4-hole mounting.

For complete information, ask for your free copy of the new Barry Product Bulletin 542, containing full installation and performance data. And for greatest benefits with these new isolators, let our Field Engineering Service help in the early stages of your equipment design.

THE **BARRY** CORP.

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WATERTOWN 72, MASS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

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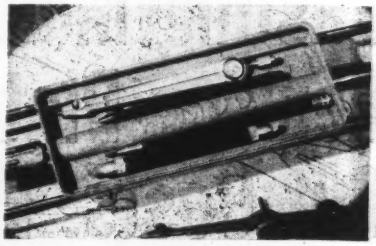
Engineering Equipment

makes of drafting machines. Tray, made of gray Royalite plastic, measures ⅝ x 3½ x 8¾ in. One



to four trays can be placed on a drafter. Made by **V. & E. Mfg. Co.**, P. O. Box 950 M, Pasadena 20, Calif.

For more data circle MD-128, Page 191

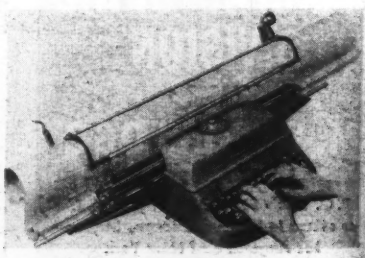
Colored Pencils

Colorama pencils, made in 50 colors, have long-wearing lead with uniform, bright color and provide smooth coverage with minimum waxiness. Various assortments of colors are offered. Made by **Eberhard Faber Pencil Co.**, 37 Greenpoint Ave., Brooklyn 22, N. Y.

For more data circle MD-129, Page 191

Lettering Machine

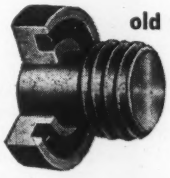
This Vari-Typer accommodates tracings 12 ft or more in length. Various styles and sizes of type are interchangeable, including sans serif drafting styles. Machine has



standard typewriter keyboard. Made by **Ralph C. Coxhead Corp.**, 720 Frelinghuysen Ave., Newark 5, N. J.

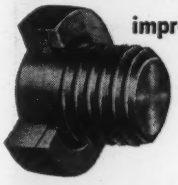
For more data circle MD-130, Page 191

Precision Dyna-seals solve plug sealing problems on NATCO HOLEPAK



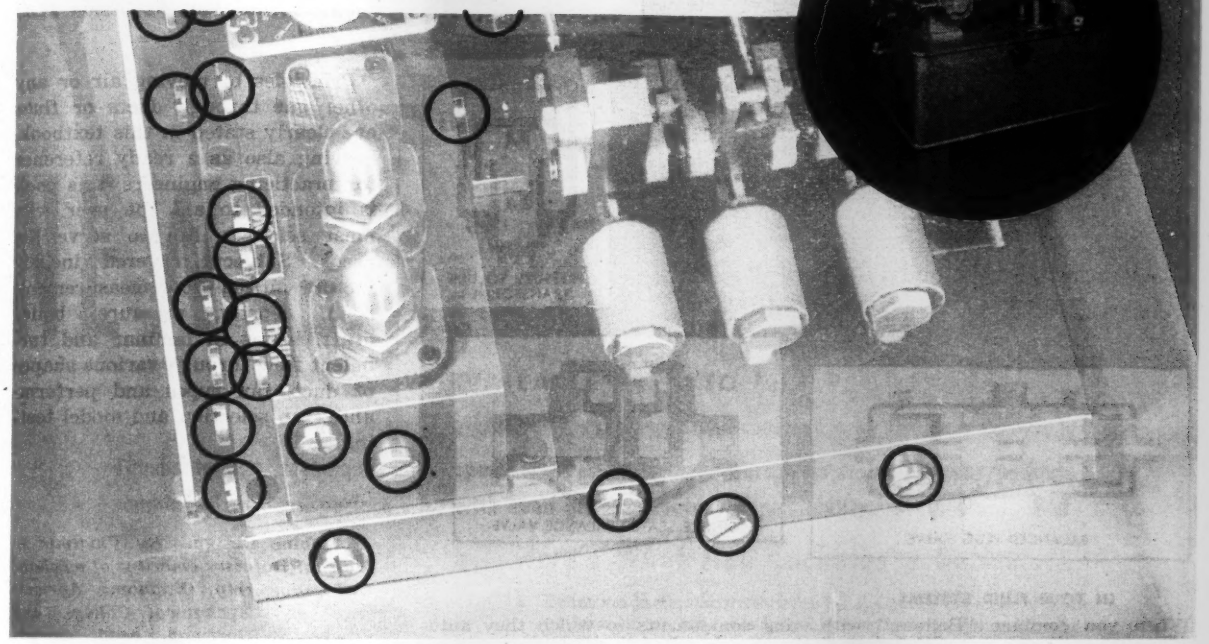
old plug design—

used an "O" Ring in a groove. Plugs were expensive, required close tolerances, permitted leakage.



improved plug design—

uses Precision Dyna-seals. Plugs are inexpensive, tolerances not critical. Assembly is much simpler, leakage eliminated.



National Automatic Tool Company, Inc. found *Precision Dyna-seals* the perfect answer to plug-leakage problems on their "Holepak" Hydraulic Control Units. There are now more than 30 *Dyna-seals* on units like the one shown here!

NATCO's improved design employing *Dyna-seals* has lowered the cost of the plugs—reduced installation and maintenance time—and completely eliminated leakage.

Why don't you let *Precision* Engineers help you put *Dyna-seals* in your designs? They assure long life and trouble-free sealing—and that means *savings!*

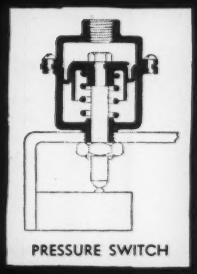
FREE—Write for your personal copy of our Dyna-seal Engineering Data booklet.

Precision Rubber Products
CORPORATION
"O" Ring and Dyna-seal Specialists

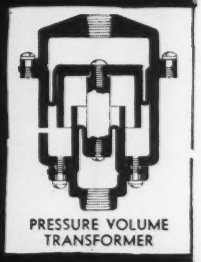
Dept. 6, Oakridge Drive, Dayton 7, O. Canadian Plant at: Ste. Thérèse de Blainville Québec

Bellofram*

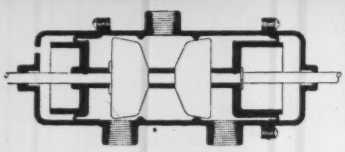
FOR FRICTIONLESS POWER



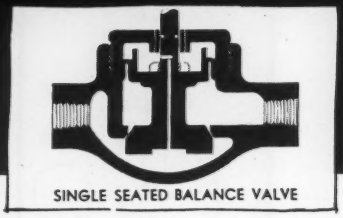
PRESSURE SWITCH



PRESSURE VOLUME TRANSFORMER



BALANCED PLUG VALVE



SINGLE SEATED BALANCE VALVE

IN YOUR FLUID SYSTEMS

When you combine "Bellows" with "Diaphragm" you get "Bellofram." This amazingly simple but new idea in Fluid Barriers performs both bellows and diaphragm functions — easier, better and simpler. A standard Bellofram can be applied to your product.

WHAT THEY ARE

Bellofram seals are long-stroke, deep convolution, constant-area diaphragms with extreme flexing life and exceptionally low spring gradient. They are relatively unaffected by foreign matter, and since they need no lubrication, they are clean. They eliminate leakage. Friction-free, rolling action gives exceptional cycle life. High dielectric strength and remarkable resistance to chemical action are important features. Area accuracy is affected only by surrounding components to which they automatically adapt themselves.

APPLICATIONS UNLIMITED

Bellofram seals may be used in almost any piston-cylinder application, for either precision measurement or frictionless power. Infrequent replacement is the only maintenance. Effective area can be controlled to within less than 0.1% over the working stroke. Efficient operation can be obtained at pressures varying from inches of water to 500 PSIG max. over a wide temperature range. Plan to incorporate Bellofram seals into both your old and new designs. A sketch of your device will help us help you. Strict confidence observed. Write today.

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144 MOODY ST., WALTHAM, MASS.

THE ENGINEER'S Library

Recent Books

Flow and Fan. *By C. Harold Berry, professor of mechanical engineering, Harvard University; 232 pages, 5½ by 8½ inches, clothbound; published by The Industrial Press, New York; available from* MACHINE DESIGN, $4.00 *postpaid.*

Principles of moving air or any other gas through ducts or flues are clearly stated in this textbook. Serving also as a ready reference for practicing engineers, this book is intended to aid the user who must select a fan to serve his needs. Subjects covered include factors in gas flow measurement, head, density, pressure, boiler draft, losses in laminar and turbulent flow through various shapes of duct, fan types and performance, fan selection and model testing.

♦

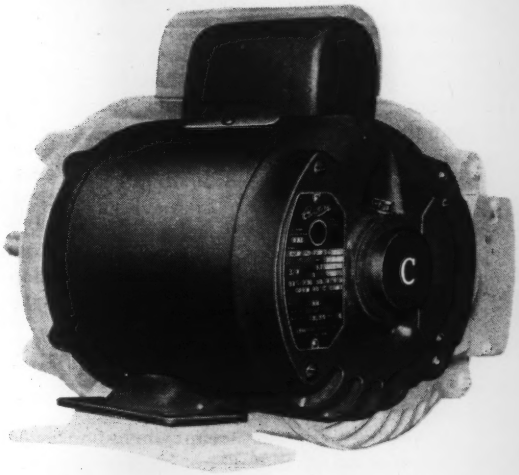
Machine Design. *By Vladimir L. Maleev, professor emeritus of mechanical engineering, Oklahoma Agricultural and Mechanical College, and James B. Hartman, head, department of mechanical engineering, Lehigh University; 720 pages, 6 by 9¼ inches, clothbound; published by International Textbook Co., Scranton, Pa.; available from* MACHINE DESIGN, $8.50 *postpaid.*

A third edition, this textbook covers mechanical aspects of the machine design field. Data on the properties and special characteristics of engineering materials and the influence of loads and other working conditions on the stresses set up in machine parts are brought together and their application to design is illustrated.

The first of six parts contains an introduction and four chapters on stresses, materials and design calculations. Part 2 is a grouping of five chapters on the manufacture of machine parts, including gen-

MORE POWER IN SMALLER FRAMES

SAVE SPACE

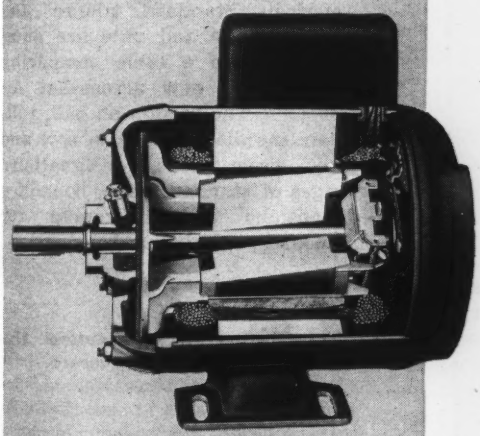


WEIGH LESS

NEW Century Form "F" Fractional H.P. Motors

NOW AVAILABLE IN ⅛ TO ¾ H.P.

Thanks to new techniques developed in the last several years, this *smaller* power package combines improved performance with even greater Century dependability.



Here's What New Techniques Deliver...

1. Better magnetic characteristics for the motor because of more uniform silicon laminated steel in magnetic cores.
2. A high dielectric and increased abrasive resistance qualities result from improved plastic insulated wire in the coils.
3. Important slot space is saved by improved plastic slot insulation. Extremely tough with higher dielectric resistance.
4. Unusual resistance to abrasion, moisture and heat is provided by improved thermal setting plastic varnish insulation on windings.
5. Squirrel cage rotors are more uniform because of improved high-pressure die-cast aluminum rotors. Individually, dynamically balanced.
6. Increased cooling ability is provided by improved ventilation.
7. These new Century Motors incorporate all mechanical features proved effective in thousands of varying applications.

For full details on Century Fractional H. P. Motors—write for bulletin 1-5 Page 1. Century also offers a wide range of types and sizes in AC and DC . . . 1/8 to 400 H.P.

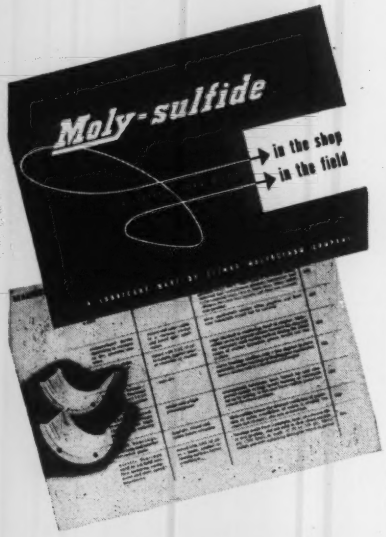
Century C MOTORS

CENTURY ELECTRIC COMPANY, 1806 Pine Street, St. Louis 3, Missouri

Offices and Stock Points in Principal Cities

832

154 ideas on ways to use...



154 varied applications of molybdenum sulfide in the shop and in the field are described in a new booklet now available. This solid-film lubricant has demonstrated unique anti-friction properties under conditions of extreme pressure, high velocity, elevated temperature, or chemical attack.

The 40-page booklet contains the records of solved lubrication problems — some might solve your own. Fill in the coupon below, attach it to your letterhead and send it off today.

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The lubricant for extreme conditions

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The Engineer's Library

eral manufacturing considerations and design of castings, weldments, riveted constructions and forgings. Part 3 deals with fastenings, which are discussed in four chapters on screw fastenings; keys; pins; cotters; press, shrink and friction joints; and springs. Details for handling fluids are covered in the fourth part with two chapters on cylinders, heads, cover plates, packings and seals. In Part 5, three chapters on hoisting machinery discuss chains, wire ropes, brakes, and screws for power transmission. Part 6, on mechanical power transmission machinery, contains fourteen chapters on shafts; couplings; positive and friction clutches; bearings with sliding and rolling contact; crankshafts; flywheels; belt and chain drives; friction gearing; straight and helical spur gearing; and bevel, worm and screw gearing.

♦

Standard Costs for Manufacturing. *By Stanley B. Henrici, manager of industrial engineering, H. J. Heinz Co.; 348 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *$5.50 postpaid.*

This second edition discusses methods of installing and operating a standard cost system. In 19 chapters this volume covers the concept of standard costs; setting up accounts; developing the standard cost system; setting standards for direct and indirect labor, materials, maintenance and other services, fuel and power; general overhead; applying standards to operations; accounting for standard costs; variance analysis; variances in labor costs, materials costs, and service and overhead costs; summary of standard cost accounting procedure; budgets; supervisors' incentive plans; and such additional features as job evaluation, cost estimating, selling prices and short cuts. Included are 29 sample forms.

♦

Handbook of Standard Time Data. *By Arthur A. Hadden, president; and Victor K. Genger, vice president; McClure, Hadden & Ortman Inc., Chicago; 488 pages, 6 by 9 inches, clothbound; published by the Ronald Press Co., New York; available from* MACHINE DESIGN, *$10.00 postpaid.*

In 15 sections, containing 65 tables, this handbook makes available detailed standard time data for establishing machine shop time values. The specific conditions have been standardized, and the standards have been verified by conventional time studies and by applications to prove their validity. These standards can be used to establish shop policies which are consistent with engineering requirements.

♦

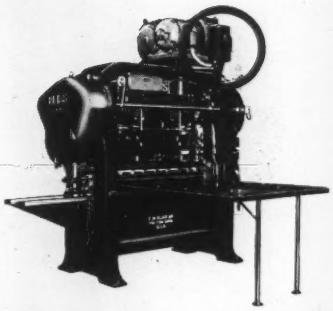
Machinery's Handbook. *By Erik Oberg and Franklin D. Jones; Holbrook L. Horton, editor;* 1917 *pages, 4½ by 7 inches, clothbound; published by The Industrial Press, New York; available from* MACHINE DESIGN, *$9.00 postpaid.*

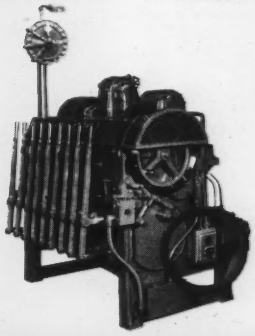
This fifteenth edition makes available new as well as established standard data and information needed by designers, mechanical engineers and builders of machines and components. Of particular interest in this edition are a revised and rearranged spur gear section and new sections on generated bevel gears, fine-pitch worms, and worm gears. Important changes in the dimensions of American Standard square and hexagon bolts and nuts are summarized, with a table comparing the old and new across-flat dimensions. The section on ball, roller and needle bearings is new and gives descriptions, designations, ranges of standard sizes, boundary dimensions and tolerances for standard antifriction bearings.

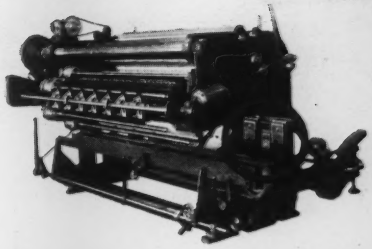
♦

Introduction to Aeronautical Dynamics. *By Manfred Rauscher, professor of aircraft structures and design, Eidgenossische Technische Hochschule, Zurich, Switzerland, formerly of Massachusetts Institute of Technology; 379 pages, 6½ by 9½ inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$12.00 postpaid.*

This thorough treatment of the







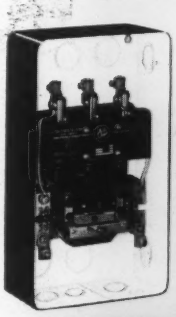
ACROSS-THE-LINE STARTERS FOR ALL TYPES OF MACHINES

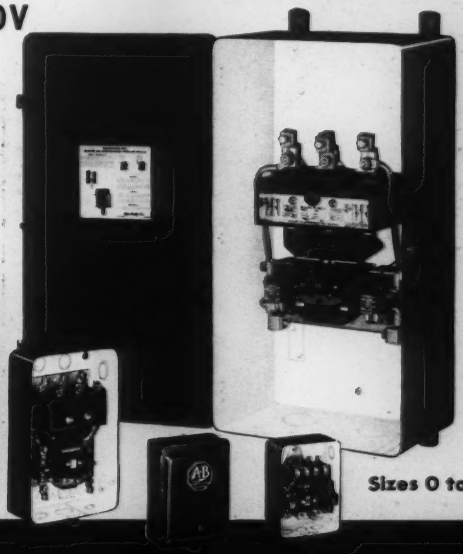
A Uniform Line up to 300 HP, 220V; 600 HP, 440-550V

It is a distinct advantage to both buyer and user of motorized machines if the across-the-line starters have a family resemblance over the entire range up to 300 hp, 220 v; 600 hp, 440-550 v. For example, Allen-Bradley solenoid starters are so nearly alike over this range that to be familiar with the structure and operation of a 5 hp starter provides equal familiarity with an Allen-Bradley 500 hp starter. This advantage is limited only to the Allen-Bradley line.

Bulletin 709 solenoid starters are available in dust-tight, waterproof, explosion-proof, and corrosion-proof enclosures.

The Allen-Bradley Handy Catalog is a handbook of control information. Send for a copy.





Sizes 0 to 5

A-B Quality

ALLEN-BRADLEY

QUALITY

Allen-Bradley Co.
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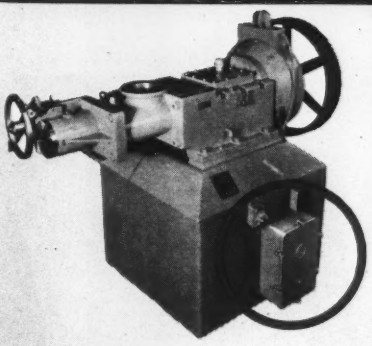
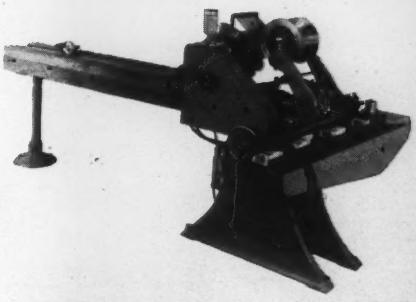
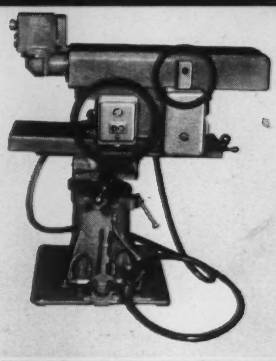
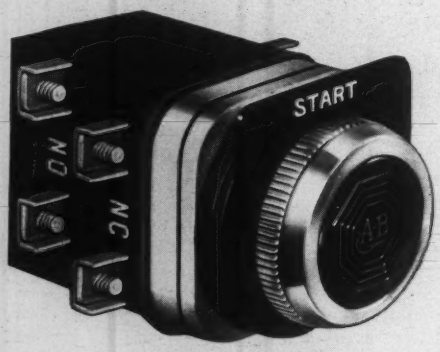




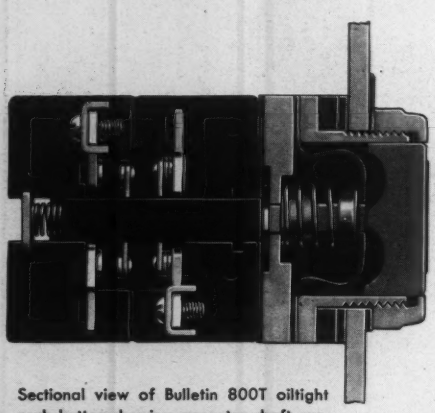


7-54-MR

OILTIGHT PUSH BUTTONS



Start Button with Double Pole NC and NO Contacts

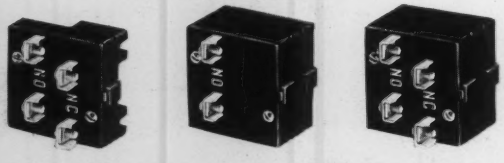


Sectional view of Bulletin 800T oiltight push button showing operator shaft carrying moving contacts. Stationary contacts are mounted in the molded contact block. The oiltight flexible diaphragm is between push button and contact block.

Assemble any combination of operators and contact blocks

OPERATORS

CONTACT BLOCKS



Bulletin 800T operators and contact blocks are available in many forms. They may be assembled interchangeably in various combinations, thus reducing your motor control parts inventory.

Here are a few of the many Allen-Bradley oiltight pilot units for machine tool service. They are available for mounting on machine frames in a variety of single units or in any combination of one or more units in oiltight enclosures. A flexible diaphragm, not affected by oil or cutting fluids, is inserted between button and contact block (see diagram at left) to prevent oil seepage into the contacts.

The silver alloy contacts are maintenance free. For complete information on the Bulletin 800T line, send for the new Allen-Bradley Handy Catalog.

Allen-Bradley Co.
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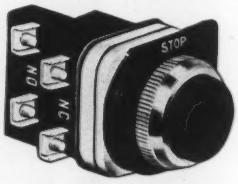
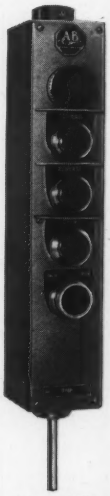


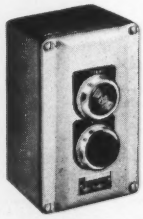
Type BA Stop Button

Type H2B Selector Switch

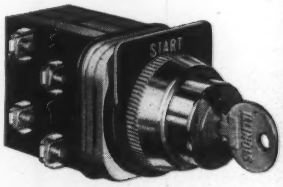
Type K2B Jog Button



Type 6PX Pendent Control



Bulletin 800T Type 2TA in Two-button Oiltight Enclosure



Type E11B Cylinder Lock Button

Type P26 Pilot Light

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subject establishes the common ground existing between fluid dynamics and aerodynamics on the one hand and the fundamental mechanics of solids on the other. Beginning with a discussion of Newton's law and the conservation of matter, the book goes on to a discussion of kinematics of a point, dynamics of a particle, dynamics of groups of particles, fundamental equations of fluid motion, stream function and velocity potential, fluid motion about simple bodies, and transformations. The remaining chapters cover airfoils, airfoils in three dimensions, viscosity, kinematics and dynamics of rigid bodies, and oscillations of systems with one and more degrees of freedom.

♦

Applied Electronics: *By Truman S. Gray, associate professor of engineering electronics, Massachusetts Institute of Technology; 909 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$9.00 postpaid.*

On the premise that proper application of electronic apparatus requires a working knowledge of the physical phenomena involved in the apparatus, the first part of this textbook, a second edition, is a discussion of those phenomena. This material is followed by an explanation of how the phenomena combine to govern the characteristics, ratings and limitations of electronic devices. The third part is a consideration of applications common to the several branches of electrical engineering. Finally, the fourth part treats semiconductor devices, primarily transistors.

♦

Induction and Dielectric Heating. *By J. Wesley Cable, consulting engineer; 584 pages, 6 by 9 inches, clothbound; published by Reinhold Publishing Corp., New York; available from* MACHINE DESIGN, *$12.50 postpaid.*

This volume covers uses and applications of high-frequency heating in industry. Divided into two major sections, dealing with induction and dielectric heating, the book contains sufficient theory to enable the reader to understand the basic phenomena applicable to both methods. Each section begins with fundamental theory of high-frequency fields and the operating principles of equipment used as sources of electrical energy.

Subsequent chapters divide the subject into specific applications: forging, melting, brazing, hardening, other metalworking operations, treatment of plastics, woodworking, food processing and others.

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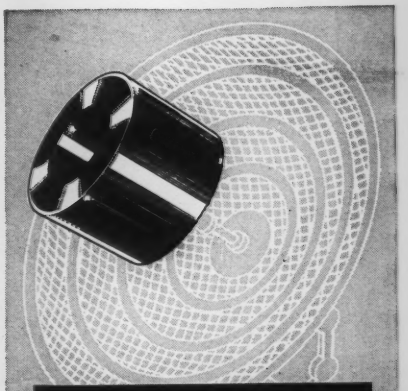
Mechanics of Materials. *By Philip G. Laurson, associate professor emeritus of civil engineering, and William J. Cox, formerly assistant professor of engineering mechanics, Yale University; 422 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$5.75 postpaid.*

The first fourteen chapters of this textbook, now in its third edition, are devoted to principles and methods used in the design of ordinary structural and machine parts, including pressure containers, riveted and welded joints, shafts, helical springs, beams and columns. The next six chapters deal with combined stresses, elastic energy, continuous beams, beams of two materials and eccentrically loaded connections. While each chapter contains appropriate problems, the last chapter consists of a grouping of comprehensive problems.

Association Publications

ELS Bibliography No. 9: Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries. *20 pages, 8½ by 11 inches, paper-bound; available from the Engineering Societies Library, 29 West 39th St., New York 18, N. Y., $2.00 per copy.*

This booklet consists mainly of a selected list of 79 references prepared for engineers and librarians concerned with organizing files. The references are to books, pam-



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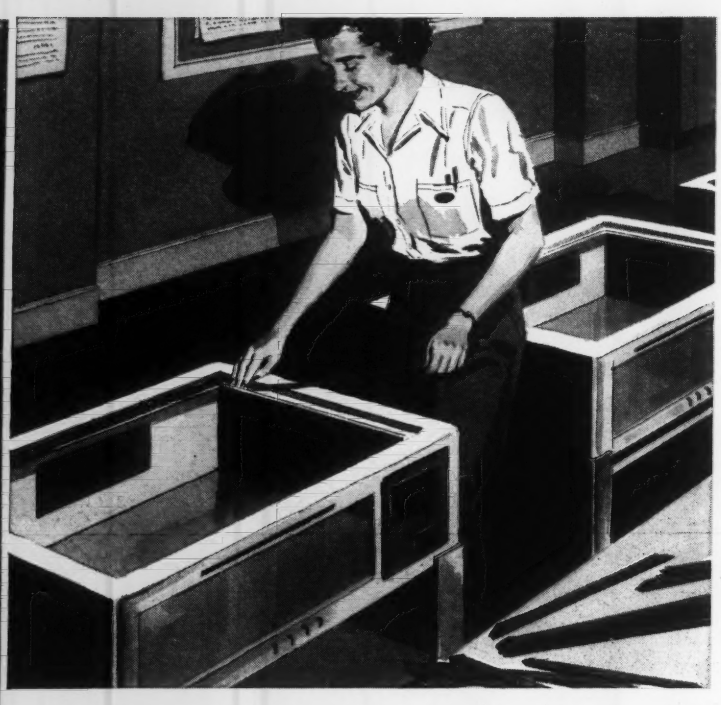

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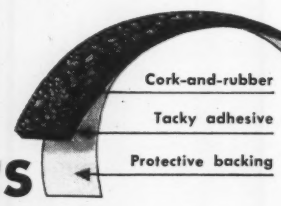

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Government Publications

Characteristics and Applications of Resistance Strain Gages. 144 *pages, 5½ by 9 inches, clothbound; copies available from the Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.,* $1.50.

This recently published book contains the proceedings of the National Bureau of Standards semicentennial symposium on resistance strain gages held in November, 1951. Included are Poisson-ratio determinations for tensile strains; cementing and waterproofing of resistance strain gages; unbonded and bonded resistance-wire strain gages; properties of concrete as measured with bonded-wire strain gages; a strain gage without transverse sensitivity; how to use G-H gages; instrumentation, commercial weighing and high-capacity load calibrating with resistance strain gages; and preliminary investigation of the strain sensitivity of conducting films.

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NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-staples; copies available from National Advisory Committee for Aeronautics,* 1924 *F. St., N. W., Washington* 25, *D. C.*

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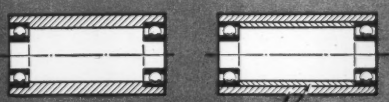

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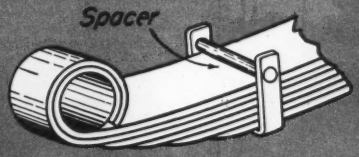
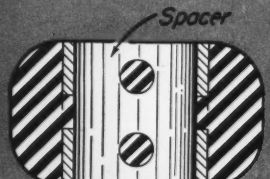


Leaf spring bolt spacer.



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Simplified Electrical Wiring

DESIGN ABSTRACTS

By Ernest A. Leavengood and Donald W. Severance

Oldsmobile Division
General Motors Corp.
Detroit, Mich.

A COMPLEX electrical wiring system can be made to appear simple when drawn schematically, but translation from the schematic diagram to an actual installation sometimes presents a difficult problem. This is especially true when the factors of wiring simplicity, ease of manufacture, safety, and ease of maintenance each must be given proper consideration. Assembly, inspection, and servicing of the electrical system of any type of equipment represents time and labor that must be spent to wire the electrical components correctly. Where methods can be found to simplify an electrical wiring system and still permit it to function properly, many problems can be solved that are of benefit both from assembly and economic standpoints.

Oldsmobile Division was faced with this problem in planning an electrical system for the 1954 model, which called for 82 separate leads as compared with 56 leads in the 1953 model.

Wiring Simplification: The first point that was considered in the redesign of the wiring system was the wire itself. The engineering aim was to find some method by which it would be easy to identify each wire with its individual terminals.

It was felt that the best way

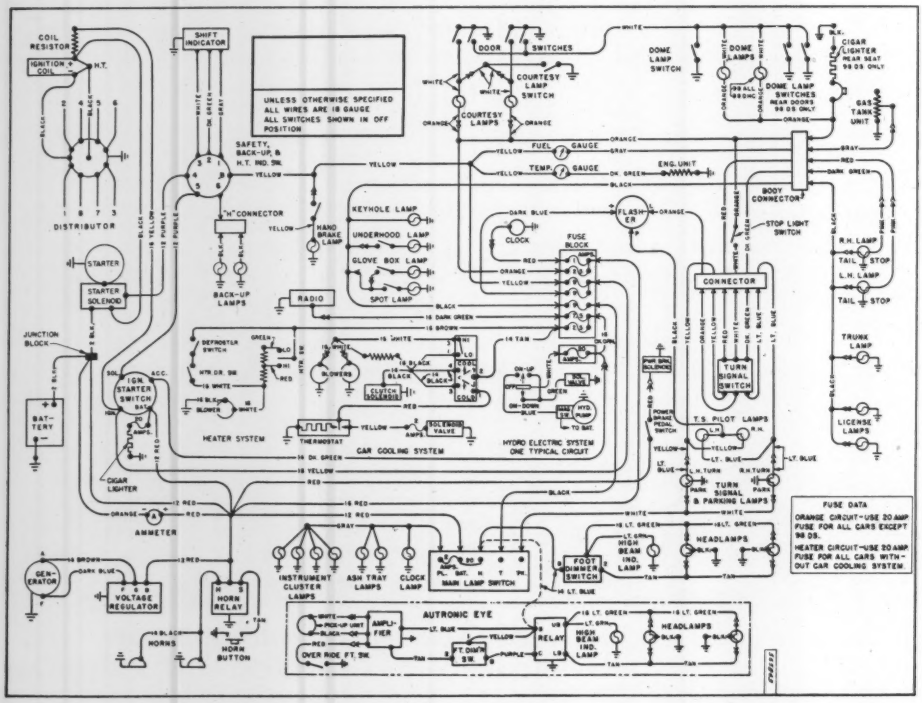

Fig. 1—Schematic wiring diagram of the 1954 Oldsmobile electrical system showing the various color codes used

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After thoroughly checking all available clutches, Drilling Accessory and Manufacturing Company, Inc., of Dallas, selected WICHITA Air-Tube Disc Clutches for their new AR-2000 Portable Drilling Unit. WICHITA CLUTCHES were selected for their compact, rugged construction and for their smoother, safer and faster operation. This rig, designed by DAMCO Engineers primarily for FAST SEISMOGRAPH SHOT HOLE, BLAST HOLE, WATER WELL, or CORE DRILLING, is the very FIRST rig of this type *to use air clutches as standard equipment*. Two 14-inch double plate WICHITA Air-Tube Clutches are used in the drums and the air for their operation comes from a compressor mounted under the truck hood.

The above photo shows the convenient controls, the platform on which the operator stands, the hydraulic pull down, and the two drums in which the WICHITA 14-inch double plate Air-Tube Disc Clutches are located.

The smooth, economical operation of this all new DAMCO AR-2000 Rig is so outstanding DAMCO has standardized on WICHITA Clutches. PROOF AGAIN THAT WICHITA CLUTCHES ARE USED BY THOSE WHO WANT THE VERY BEST.

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Oil Field Motor Service, Alice, Texas
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Industrial Air Controls Co., Ft. Worth, Texas

to simplify the assembly and inspection of the wiring system, and also improve its appearance, would be with the use of a color code to enable easy matching of wires and their terminal points. In studying different wires, it was found that the vinyl plastic insulation of a new type of wire was available in a wide variety of colors. Tests showed that, after long periods of exposure to actual service conditions, the colors of the vinyl plastic still could be identified easily. This reason, plus the fact that the new wire possessed other advantages over the braided type, led to its adoption.

The use of a color code has also been extended to other component parts of the electrical system. Color dots are provided on the instrument cluster, ignition switch, fuse panel, light switch, and ignition resistor. This practice has substantially reduced assembly and service time as it is now a matter of merely connecting "the red wire to the red terminal." The inspection procedure likewise is simplified since colors of wire and terminals must match if the wiring operation has been done correctly. The schematic wiring diagram of the 1954 Oldsmobile electrical system and the various color codes are shown in *Fig.* 1.

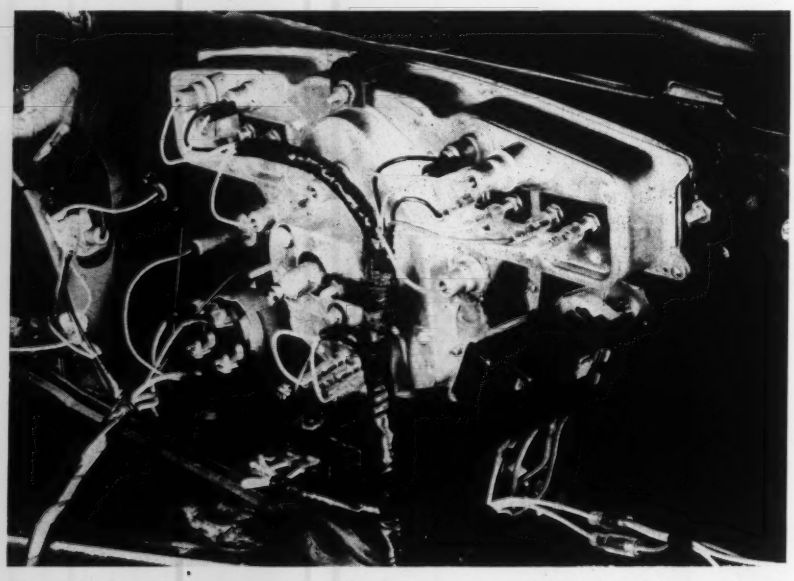
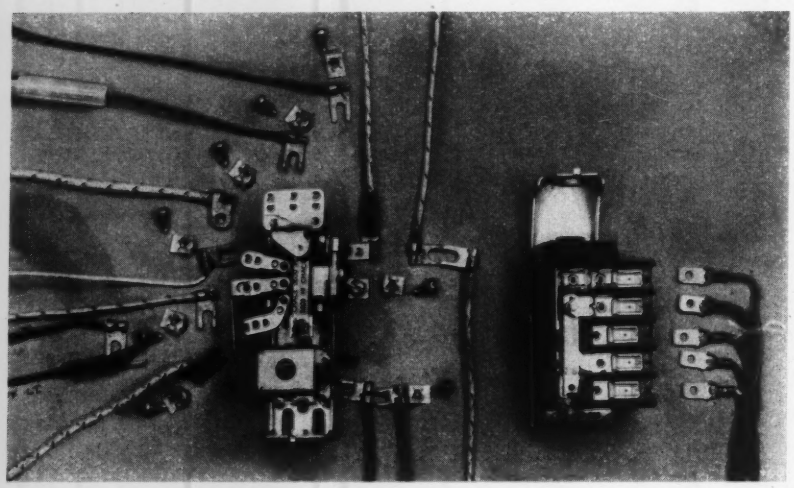


Fig. 2—Above—Instrument-panel wiring on the 1954 Oldsmobile as viewed from the rear. Simplicity, ease of assembly and improvement in appearance have been achieved through the use of a redesigned system in which most of the electrical-accessory wiring has been combined as an integral part of the main wiring harness

Fig. 3—Below—Neat appearance of the 1954 light switch (right) as compared to the 1953 switch (left) is due to the number of terminals being reduced from nine to five and the number of wire leads from thirteen to five



Circuit Arrangement: The use of a color-coded wiring system aided in simplifying the assembly, inspection, and servicing of the wiring system, but engineering revision went still further in an effort to improve the overall electrical system.

A careful study of the 1953 wiring circuit led to a simplified circuit arrangement on the 1954 models. Now, most of the electrical-accessory wiring has been combined as an integral part of the main wiring harness. This reduces labor time on the assembly lines since separate installation and routing of the many accessory wires is no longer required. Because most of the accessory wiring is now an integral part of the main wiring harness, simplification in assembly and a neater appearance has been made possible. This can be seen in *Fig.* 2 which shows the new instrument panel wiring arrangement, as viewed from the rear. The wire leads from the harness are in an orderly arrangement and the color-coding of wires allows for ease in tracing in the wiring setup.

Engineering investigation also was directed to the wiring of the starter which, prior to 1954, had been difficult to work on because of its location beneath the engine. Proper inspection of the wiring after assembly also was difficult for the same reason. To improve this situation and solve the assembly and inspection difficulties, the 1954 model now uses a battery-cable junction block mounted on the left-hand filler plate. This design permits the complete wiring and inspection of the starter before it is installed on the engine.

The assembly phase of joining the car body wiring to the chassis electrical system was given con-

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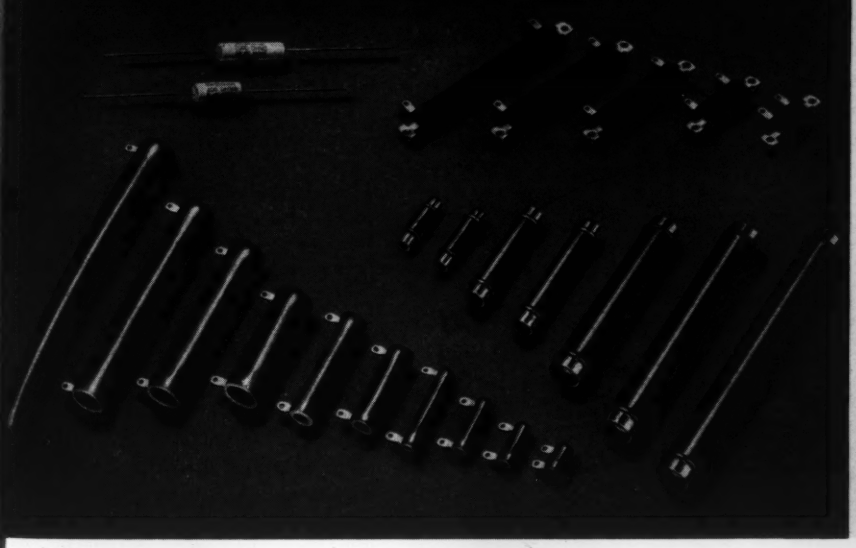

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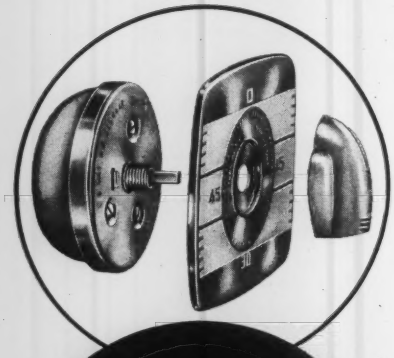

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Design Abstracts

sideration. Investigation of this particular part of the electrical system led to a newly designed device which makes use of a multiple-contact disconnect plug. All wire leads in the car body now terminate at this plug and the body is connected to the chassis electrical system by merely pushing the mating halves of the plug together. The multiple-disconnect halves are keyed to prevent improper assembly.

The main light switch terminals on previous models created a problem in assembly by requiring the time-consuming operation of placing from one to four wires under a single screw head. Because of the decreased current requirement of the 12-volt electrical system as used on Oldsmobiles, it was found that single push-on type terminals could be used effectively to replace the former method. The use of this type of terminal has simplified both assembly and inspection as well as decreasing the time required to perform these two operations. The redesigned light switch also reduces the number of switch terminals from nine to five and the number of wire leads from thirteen to five. The simplicity and neat appearance achieved in the 1954 light switch, as compared to the 1953 switch, is shown in *Fig.* 3. The terminals are clearly marked with bright colors to match the attaching wire color.

The individual, in-line type fuse holder on previous models was another item that created problems in assembly, inspection, and service. The 1953 Oldsmobile, equipped with all of the electrical accessories available to the customer, had a total of 19 fuses in different locations. Many of the fuses were difficult to locate because they were obscured by the car wiring. The majority of the fuses were of the in-line type and difficult to take apart since it was necessary to use both hands in performing the operation behind the instrument panel. The subject was studied carefully in an effort to improve the condition. The result was a newly designed combination junction block and fuse panel, which is shown in *Fig.* 4. The new design centralizes the fuses and circuit junction points and also employs the use of push-on type connectors. In contrast to the number of fuses on previous models, the new design uses only seven fuses on the panel and one instrument-light fuse located on the light switch to protect the dimmer resistor. The fuse panel also has all circuits clearly labelled and a color-code system similar to that found on the light switch.

Since it is not possible to include names on the fuse panel of all items protected by a single fuse, the new color code enables the service man simply to observe the color of the wire at the point where service is required. The fuse which may require replacement is identified by a color dot on the panel to match the wire color.

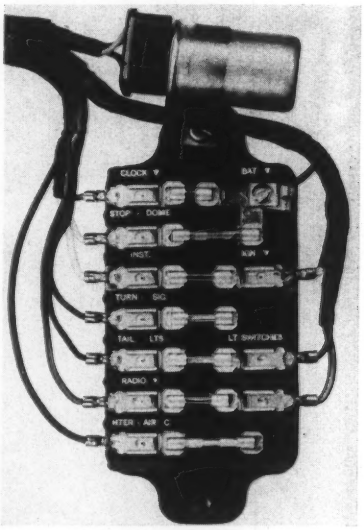
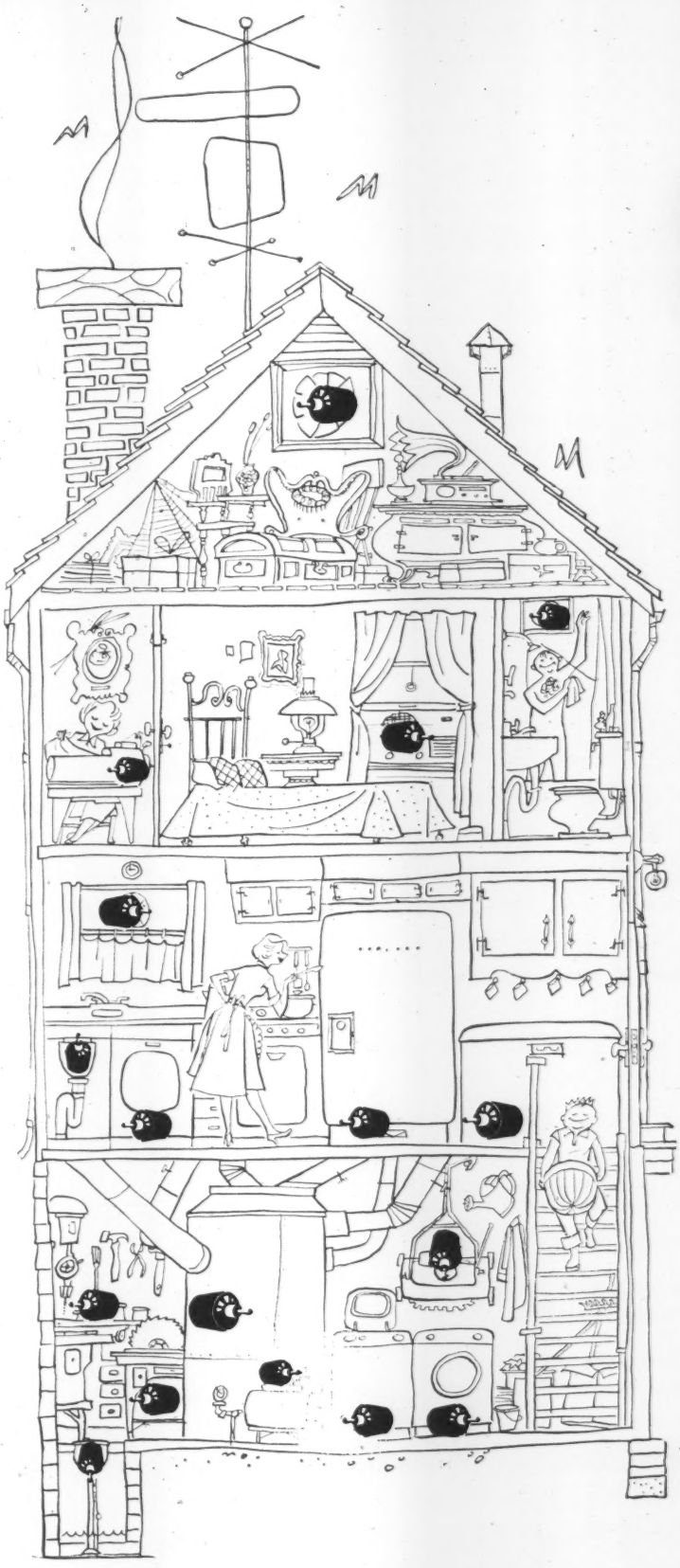


Fig. 4—Combination junction block and fuse panel simplifies fuse replacement and eliminates possible short circuits through the use of molded bakelite barriers between push-on type terminals

New Safety Features: The engineering investigation of the 1954 wiring and electrical system was not devoted wholly to designing electrical components that would simplify assembly, inspection, and service. The topic of safety also was considered and many new safety features have been incorporated into the new system.

The possibility of short circuits



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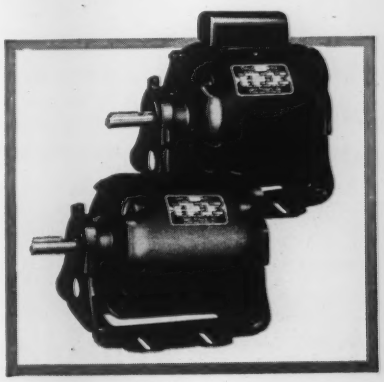

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Design Abstracts

has been virtually eliminated by the newly designed main light switch. The switch terminals are recessed between molded bakelite barriers to prevent the possibility of short circuits to adjacent terminals. The bakelite barriers also provide protection from accidental shorts caused by misplaced bowden cables and wire clips. The combination junction block and fuse panel also has the molded bakelite barrier provision which serves a two-fold purpose. The barrier affords the same protection against possible short circuits as in the main light switch and also eliminates the necessity for a protecting panel cover which, in turn, allows for easy inspection and service of the fuses.

As an added safety precaution, all body wiring—with the exception of the seat-adjusting motors and convertible-top actuating motors—now is fused. This insures maximum protection from possible fires that might result from partially or intermittently shorted strands of an electric cable.

Final Results: The overall results of the engineering revision of the wiring and electrical system have proved beneficial. All of the new features have led to simplification in assembly, inspection, and service. Safety, as it involves the electrical system, has been improved with the new design of the electrical-system components.

In general, screw-type connections have been reduced to a minimum throughout the entire electrical system in favor of push-on types, thereby reducing assembly time and eliminating the human factor of loose connections caused by failure to tighten screws properly. The time required for service work has been reduced also as a result of the new system. The color dots which are provided on the various electrical components aid in indicating the correct wire colors which should be used when wiring the units.

A further benefit which has been derived from the new wiring and electrical system is the simplification which has resulted in the employee-training program. After one trial, men have been able

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to wire instrument panels correctly without further reference to instructions or drawings.

Assembly, inspection, and service time have been reduced with the introduction of the color code. The redesigned light switch eliminates any possibility of miswiring and prevents short circuits. The use of a battery-cable junction block has simplified starter wiring. The newly designed combination junction block and fuse panel, with the push-on terminals, has decreased and centralized the number of fuses necessary.

As in the case of all engineering work, economic considerations must also enter the picture. Original estimates indicated that the time saved on the production line would more than offset the cost of the new wiring and electrical-system components. Early production experience indicates that this estimate was correct.

From an article entitled "Designing Simplicity, Ease of Manufacture, and Safety into an Automotive Electrical System" which appeared in General Motors Engineering Journal *for March-April,* 1954.

Porcelain Enamel Applied to Aluminum

By B. C. Bricker

Ceramic Products Div.
Electrochemical Dept.
E. I. du Pont de Nemours & Co. Inc.
Wilmington, Del.

A PORCELAIN enamel for aluminum has been developed which combines all the good properties, surface hardness, durability and chemical resistance of glass with the light weight, workability and strength of aluminum. The many possible applications for this vitreous enamel become more apparent upon examination of some of its unusual and outstanding properties. It offers excellent workability. Porcelain enamel on aluminum will not chip or flake and can be fabricated much as is uncoated aluminum. It is spall resistant and can be plunged into cold water from elevated temperatures with no detrimental effects on the coat-

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ing. The enamel imparts additional flexural strength to aluminum. Porcelain enamel can be applied over welds. Field installations have been in service for over six years with no signs of deterioration. Shipping and packaging costs are low. Porcelain enameled aluminum is finding acceptance in many design engineering applications such as electrical shielding, household appliances and similar equipment.

From a paper entitled "Vitreous Enamels for Aluminum" presented at the Twenty-Sixth Annual Meeting of the Lead Industries Association in Chicago, Ill., April, 1954.

Applying Chromate Conversion Coatings

By C. W. Ostrander

Service Manager
Allied Research Products Inc.
Baltimore, Md.

CHROMATE conversion coatings are coatings formed by immersion of metal in an aqueous acidic chromate solution, consisting substantially of chromic acid or a bichromate plus other active radicals for chemical treatment.

General Advantages: Chromates and bichromates in aqueous solutions have long been noted for their powerful inhibitive influence on ferrous and other metals when used in an alkaline solution. Minute quantities of these compounds in closed water systems such as radiators will passivate the metal surface against the formation of corrosion products.

Chromate conversion coatings utilize the same passivating characteristics of alkaline chromate solutions, but approach the problem from the opposite side of the pH scale. When the metal is immersed in an acid chromate solution, a chemical reaction takes place which actually converts and deposits a complex chrome gel on the metal surface.

Zinc, cadmium, aluminum, magnesium, copper and copper alloys can be treated in this manner, providing them with highly protective coatings of decorative value, plus

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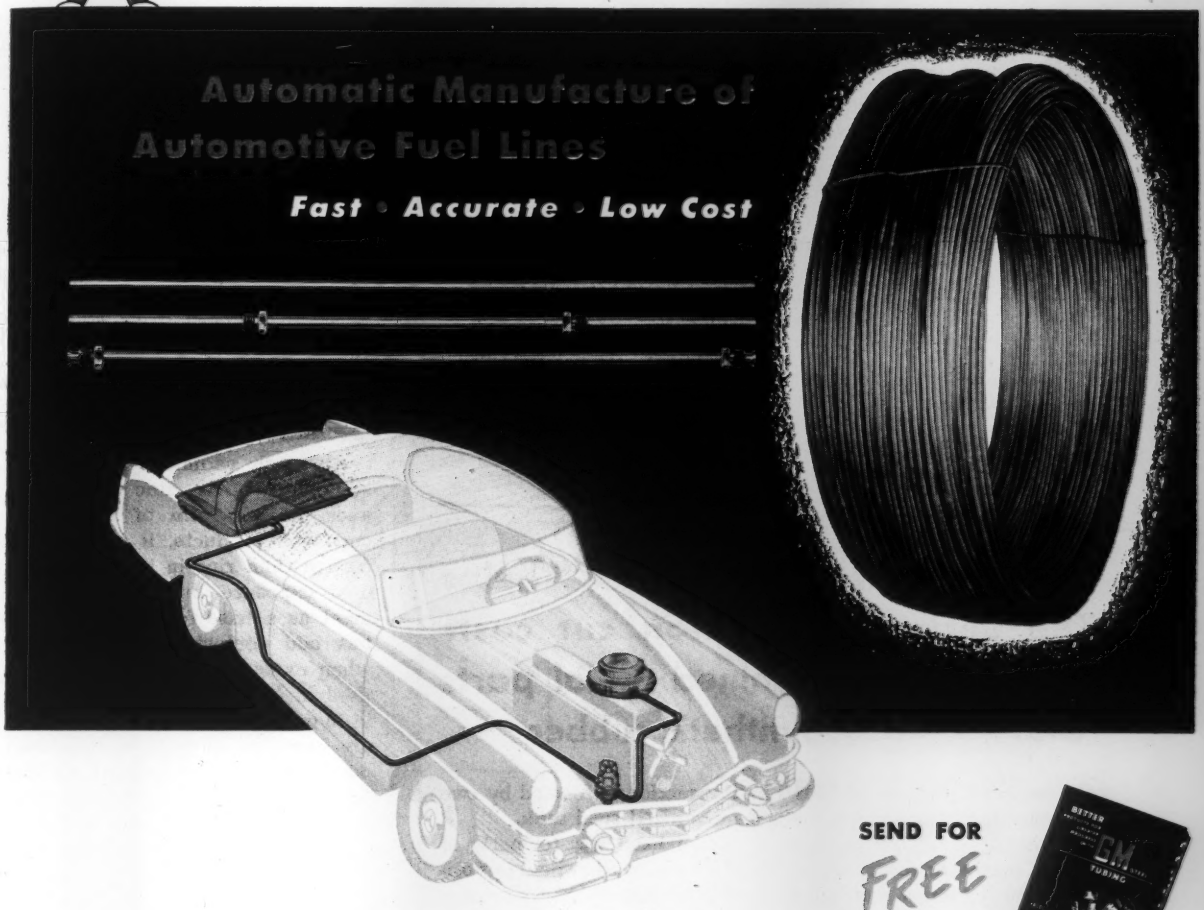

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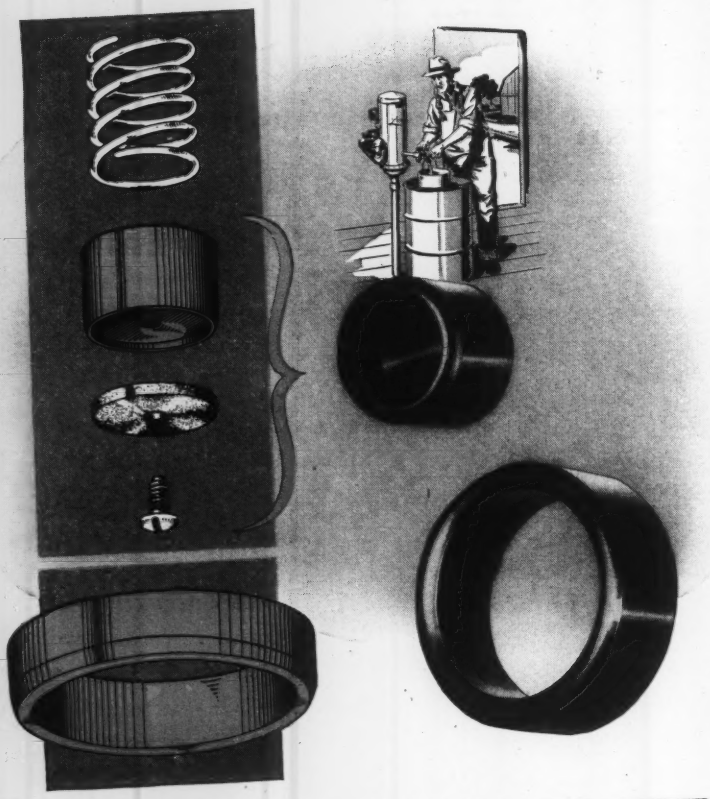

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P-4

Design Abstracts

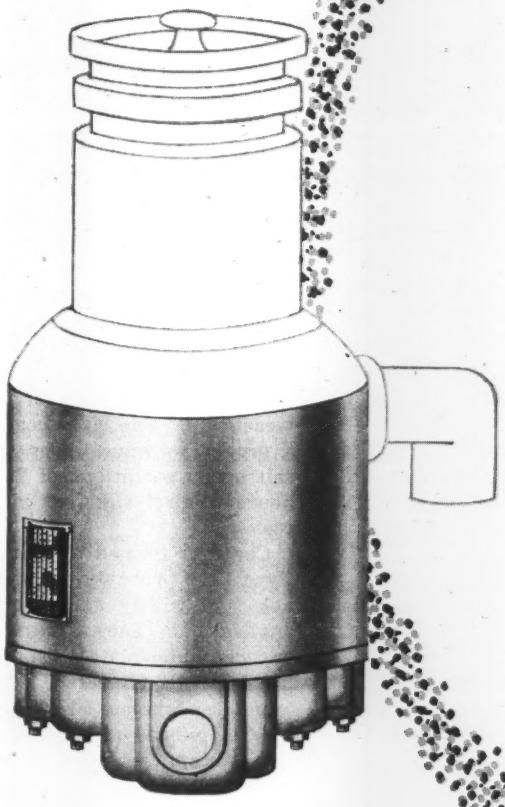
excellent bonding characteristics for further organic finishing. The extensive use of these treatments has occurred as the result of a rapidly growing demand for a more stable final finish providing increased corrosion protection and organic bonding superior to that of the metal itself.

For a long time one of the most effective methods of protecting iron and steel from rusting has been the application of a zinc coating; this is accomplished either by electroplating or hot dip galvanizing.

The use of chromate conversion film on zinc was one of its first extensive commercial applications. Chromate solutions will chemically polish and passivate the zinc surface, providing a resultant finish closely approaching bright chromium plate in appearance, which is highly desirable from a decorative point of view.

Although cadmium has certain advantages over zinc in appearance, in the form of its marine corrosion products, it is less protective than zinc in industrial outdoor exposure and is no improvement as a base for paint. It also has odd corrosion characteristics when exposed to vapors of phenol used in insulators by the electronic industry. Consequently, chromate coatings have been developed which benefit cadmium to the same extent that zinc is benefited. The closest competitor of chromate coatings are the phosphate treatments, and although they do provide an excellent base for paint, they have little or no protective value and therefore do not compete in this category.

Application of Coatings: The usual operating procedure before applying chromate conversion coatings consists of electroplating such metals as zinc and cadmium, or in the case of hot dip galvanize, zinc die castings, aluminum, magnesium, copper and copper alloys, followed by a thorough cleaning in an alkaline solution followed by rinsing and an acid pickle if necessary. The surface to be treated is then immersed in the acidified chromate dip for a period ranging



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from a few seconds to a few minutes depending upon the metal being processed and the treatment used. This is followed by rinsing and drying.

Surfaces can generally be processed by rack, bulk, automatically and, in some instances, by brushing or spraying. This simple operating procedure has allowed chromate conversion coatings to be practical in an almost limitless range of production conditions.

About 99 per cent of the chromate conversion coatings for zinc, cadmium, aluminum, copper and copper alloys used today are proprietary mixes. These are supplied either in concentrated liquid form or as a powdered compound.

Coatings for Zinc and Cadmium: Dip chromate conversion treatments for zinc and cadmium can be separated into two very simplified groups on the basis of acidity.

Group Number I Coatings operate within a pH range of 0.0 to 1.5 and produce lustrous chemically polished surfaces having clear to iridescent yellow finishes. Where desirable the yellow iridescence can be eliminated by the use of a dilute acid or alkaline bleach dip. The clear coating has a protective value under standard salt spray conditions of 24 to 100 hours to first signs of white corrosion.

Coatings formed by solutions of Type I are probably the most valuable and widely used for civilian application. They provide zinc and cadmium plate with the clear highly lustrous surface which has long been associated with quality by the public, and closely resembles chromium plate in appearance. The results obtained from this type of treatment are greatly enhanced by smooth or polished base metal and dense fine-grained cyanide zinc plate. Minimum plate thickness of two to three ten thousandths of an inch are recommended. Where continual wear or surface abrasion is a problem, a clear organic finish can be used. The many bright dips available afford a broad range of application, operation and cost. Finishes of

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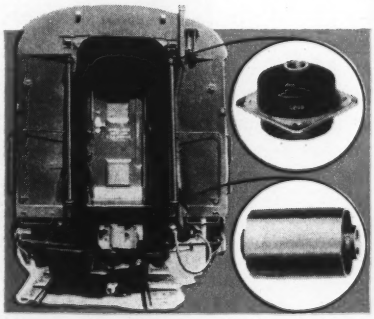

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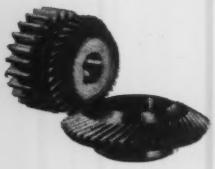

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Design Abstracts

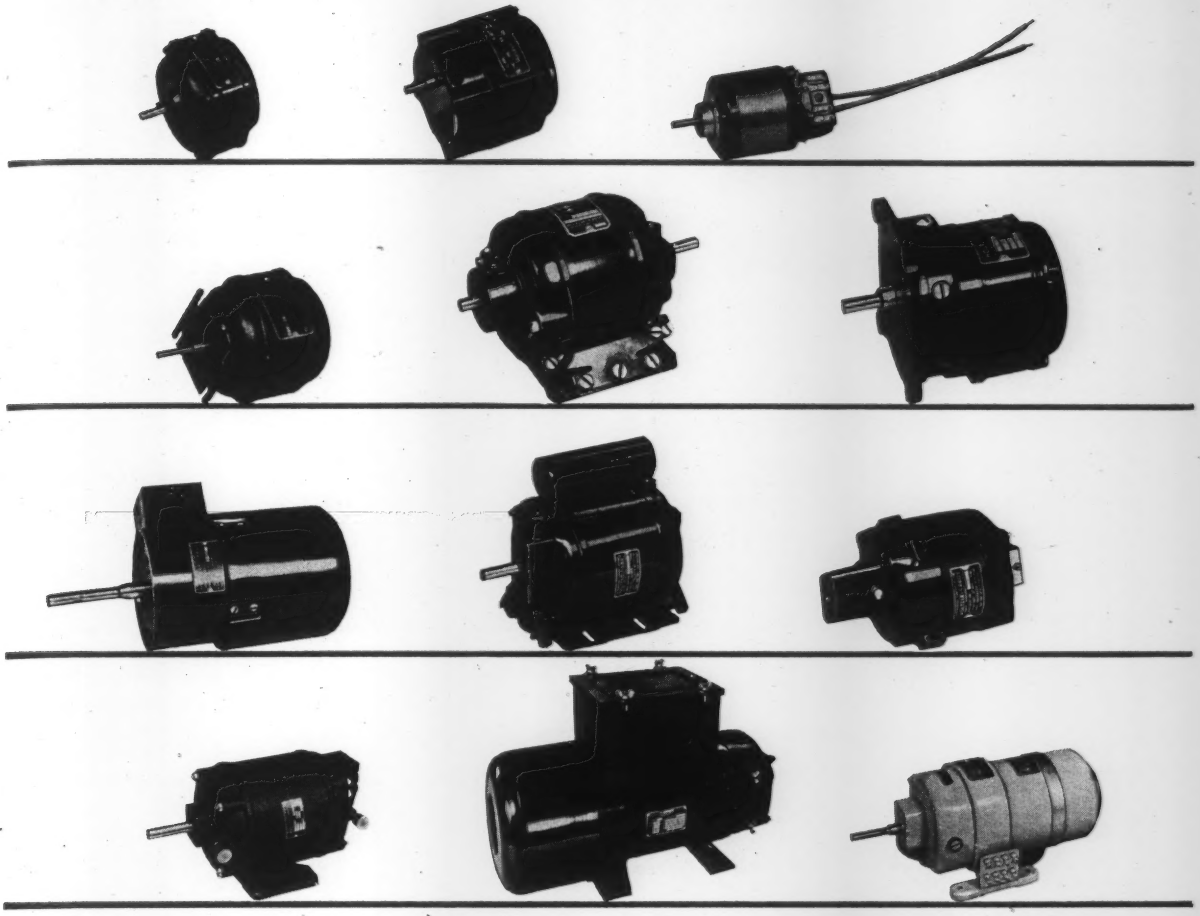
this type have found wide application in the field of electronic equipment on such items as radio and television chassis and speaker units; home utilities; automobile, motorcycle and bicycle parts; office machines; hand tools; hardware; nuts and bolts; wire goods; and plated strip on other articles.

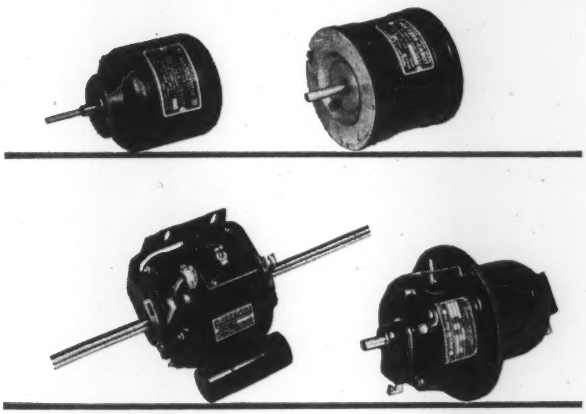
Clear bright coatings on cadmium, although not as widely used, are extremely valuable in reducing oxidation during storage. The finish thereby provides a surface which can be readily soldered with rosin fluxes and have found wide application in the electronics field.

Group Number II Coatings operate within a pH range of 1.0 to 3.5, are non-polishing and produce medium to heavy coatings ranging in color from iridescent yellow through bronze to olive drab, and provide maximum protection against corrosion, ranging from 100 to 300 hours under salt spray conditions.

Coatings of Group II through their simplicity of operation, broad range of appearance, and high protective value are an essential part of zinc and cadmium finishing. Uses include zinc die-cast parts such as carburetors and fuel pumps. Such items as washing machine parts, mixers, juicers, dispensers, wire goods and a great variety of military items covered by government specifications can be included.

Coatings for Aluminum: Chromate treatments for aluminum are usually available as powdered proprietary compounds. Basic colors obtainable vary from a clear colorless coating using a 10-second immersion time to a yellow coating obtained at three minutes. Coating time can be extended from three to six minutes and the resultant coating colored by a water-soluble dye. The protective value of the three-minute yellow coating equals that of a 20 to 40-minute anodized oxide coating. The corrosion protection obtained in both treatments will vary according to the alloy processed. This is usually inversely proportional to the copper and iron content. The





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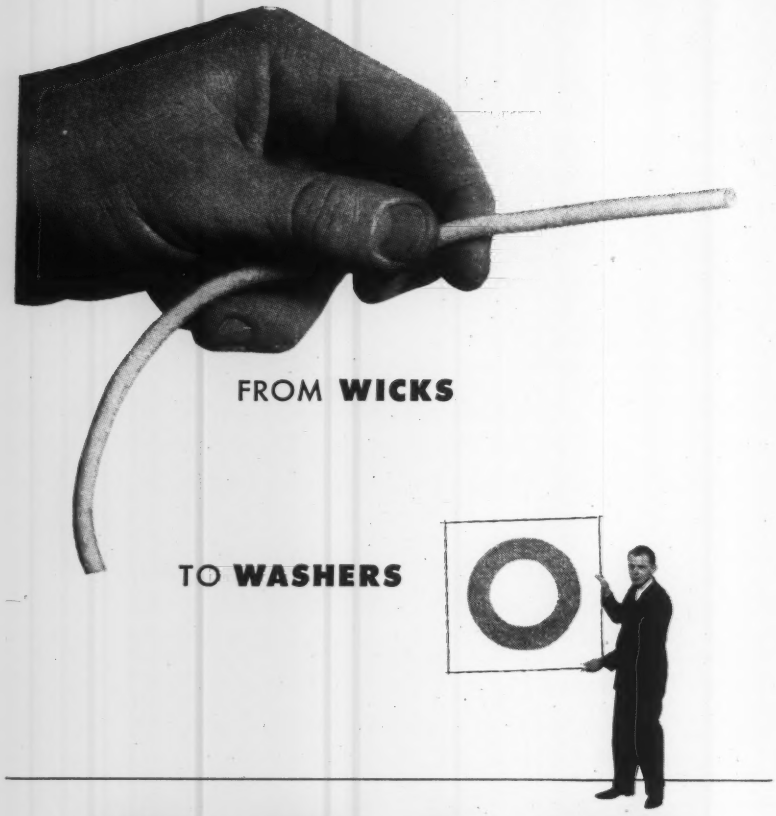

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The "Felters Design Book" contains interesting information about several grades of Felt and their uses. We will be glad to send you a copy. Write today. THE FELTERS CO., 218 South St., Boston 11, Mass.

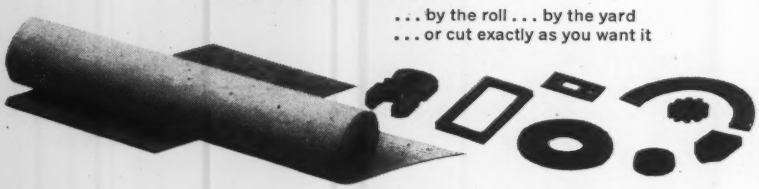
FELTERS S.A.E. F-1 FELT

is a grade suitable for oil retention where the felt is not compressed, for feeding light oil, or where unusual strength and hardness are required. Often recommended for use in resisting wear and abrasion.

This is one of many grades of Felters Felt produced for specific applications.

FELTERS FELT

. . . by the roll . . . by the yard
. . . or cut exactly as you want it



Design Abstracts

chromate treatment can be applied by rack, bulk, brush, spray or steam gun; the anodized parts muct be racked on aluminum racks having good electrical contact. The chromate finish is relatively soft and has the low electrical resistance of 1900 microhms per square inch at 100 psi, while the anodized coating proved to be in excess of 99 ohms, eliminating it as a surface for electrical contact unless cut through. The resistance obtained with the chromate finish is low enough for ground applications in many cases, as well as on shields and wave guides. This combination of conductivity with corrosion resistance has made chromate treatments invaluable for applications in the electronics industry. Chromate coatings also have been found to provide an excellent base for paint and rubber bonding.

The scope of acceptance as a finish for aluminum includes aircraft, electronic and domestic fields. One interesting application is on scratched, machined or otherwise abraded anodized surfaces for providing corrosion protection or a point of electrical conductivity.

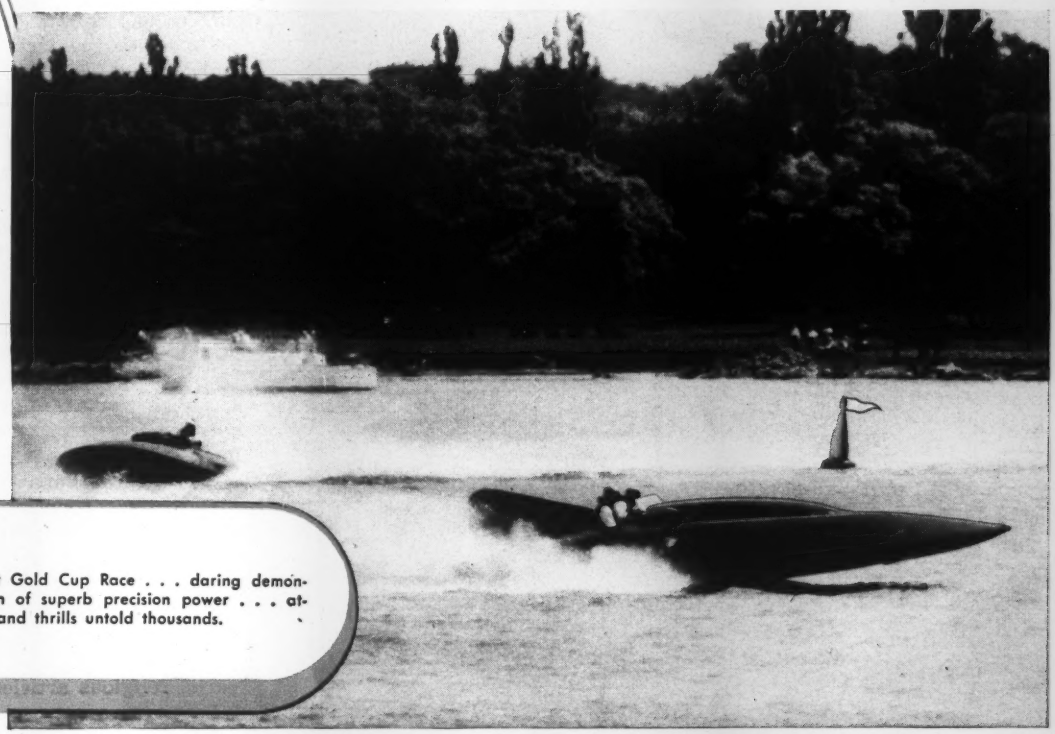
Coatings for Magnesium: The majority of treatments for protecting magnesium have been developed and are provided by the Dow Chemical Companies, Magnesium Department. Some work has been done by suppliers of proprietary chromate treatments and one was recently released as a proprietary compound.

Dow 7, the standard treatment which provides comparable corrosion protection, is applied as a 30-minute treatment in a boiling bath of bichromate. A lustrous brown coating results, which is characteristic of this treatment.

The proprietary mix is operated at room temperature and, using a 15-second to 2-minute immersion time, produces a relatively lusterless brown coating. Rinsing must be thorough, since the coating solution contains hydrochloric acid. Both coatings provide good corrosion resistance and paint base. The proprietary film exhibits very low electrical resistance

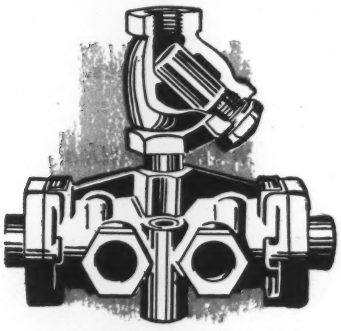
LOGAN . . . a national participant in major fluid power advancements

SINCE 1916



Detroit Gold Cup Race . . . daring demonstration of superb precision power . . . attracts and thrills untold thousands.

LOGAN AIR CONTROL VALVES



Model 6245—4-Way, 2-Position

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- COMPACT DESIGN
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79 MODELS

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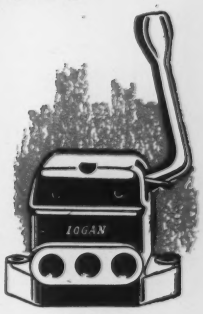

Model 6540
4-Way, 2-Position

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SAVES TIME — Logan — AIR AND HYDRAULIC EQUIPMENT — EFFORT • MOTION

LOGANSPORT MACHINE CO., INC., 811 CENTER AVE., LOGANSPORT, IND.

CROWD! HOIST! SWING!

Crowd, hoist, swing—*crowd*, hoist, swing—millions of times a day on jobs in construction, mining, and materials handling, rugged shovels slam the horsepower of powerful engines through hard-working clutches. Jobs like this call for tough, precision clutches, built to withstand loads *beyond* rated capacities. That's why more shovel builders and buyers *standardize* on Twin Disc "E" and "EH" Heavy Duty Clutches—with wider, better-finished surfaces; heavier, more compact construction.

Whether you're building shovels or other equipment . . . or using them . . . you'll profit by specifying Twin Disc Friction or Hydraulic Drives . . . developed from 35 years of specialized experience, backed by 8 Twin Disc Factory Branches and 60 Twin Disc Parts Stations.

Lima-Hamilton Division, of Baldwin-Lima-Hamilton Corp., incorporates Twin Disc Clutches in many products, including Heavy Duty Model "E" Clutches in its Paymaster Shovels. Write for Bulletin 108-F.

TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

and an excellent base for rubber bonding.

Coatings for Copper: Chromate treatments for copper and copper alloys are usually available as proprietary liquid concentrates. These are made up and operated similar to other chromate treatments. The treatment will produce a passive surface and will, if desired, chemically polish the surface to a very high luster. This offers a great advantage over the badly fuming nitric-sulphuric-hydrochloric dip customarily used. Maximum polishing is obtained only on fine-grained homogeneous alloys. Alloys having a heterogeneous structure will result in a satin rather then a lustrous surface.

Chromate treatments can be used as a final finish or can be bleached off and the resultant surface used as a base for subsequent nickel or chrome plating. The chemical polishing action will reduce and sometimes eliminate the need for hand buffing.

Chromate conversion coatings are used by the automotive industry prior to chrome plating to produce an active lustrous surface for chrome plate. The protective films are used on such items as welding tips, fire extinguisher parts, religious articles, and many others.

From a paper entitled "Chromate Conversion Coatings" presented at the Twenty-Second Annual Meeting of the American Society of Tool Engineers in Philadelphia, Pa., April, 1954.

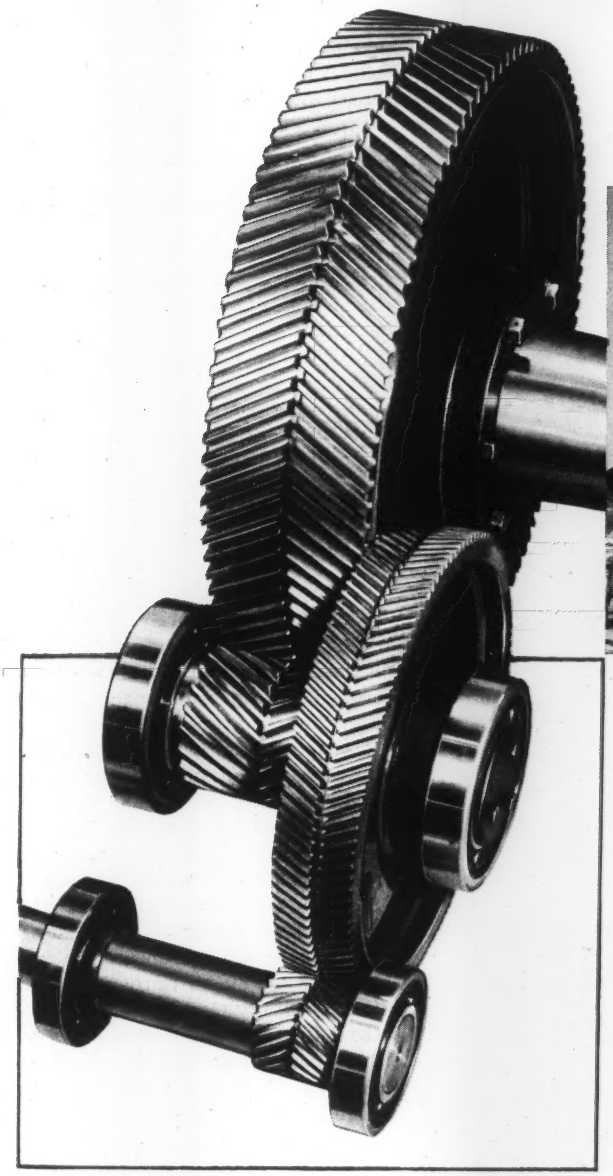
Design Considerations for Carbon-Graphite

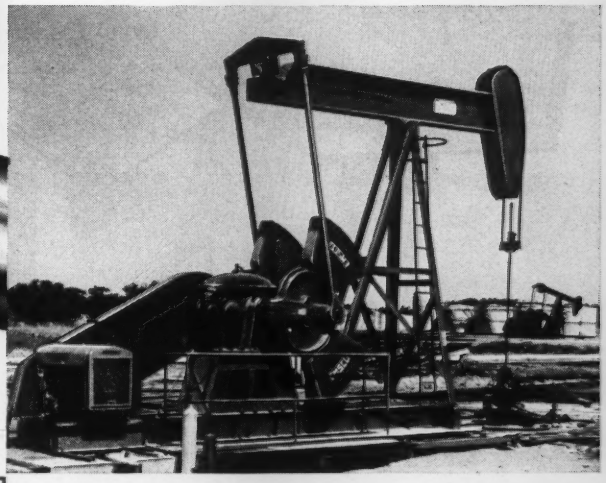
By Fremont F. Ruhl

United States Graphite Co. Div.
The Wickes Corp.
Saginaw, Mich.

CARBON-GRAPHITE is made from carbon and graphite powders, bonded with a hydrocarbon bond that has been carbonized. Therefore, chemically speaking, it is all carbon including the binder. A wide variety of carbons can make up the original ingredients.

FLOATING ON HYATTS!





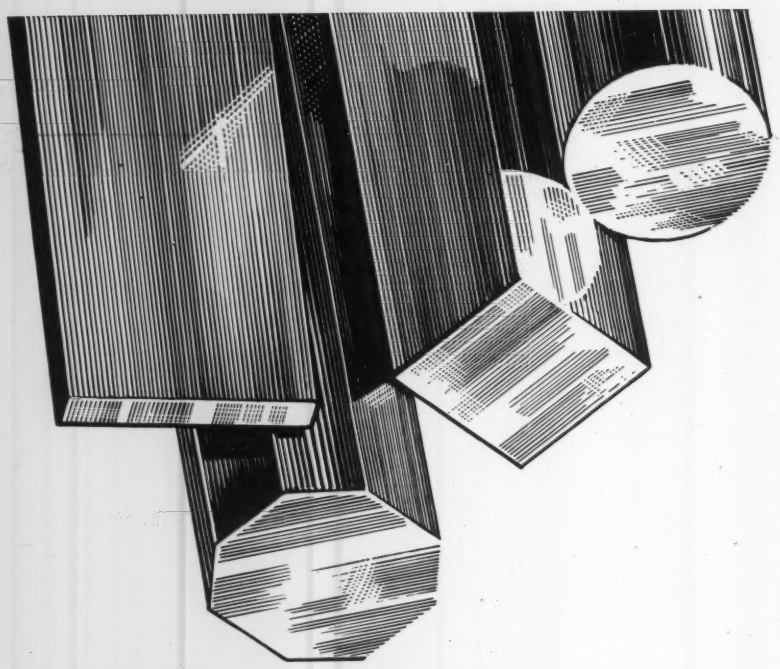
This is a job for straight roller bearings, and EMSCO relies on HYATTS!

Take a good look at these herringbone gears—and at the four bearings supporting the two smaller shafts. These particular herringbones operate in the gear box of EMSCO's newest pumping unit, and the bearings are *Hyatt Hy-Loads!* For oilmen, this is a combination that means longer bearing life and lower maintenance costs, because only *straight radial bearings* permit these gears to locate themselves for most efficient operation. And when the application calls for radial-type bearings, EMSCO engineers specify Hyatts. Hyatts offer the proven advantages of easy assembly, simple maintenance, complete interchangeability of parts, and longer life. Insist on Hyatt Hy-Load Bearings for herringbone gear applications.

HYATT ROLLER BEARINGS

STRAIGHT ◯ BARREL ◯ TAPER ◯

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



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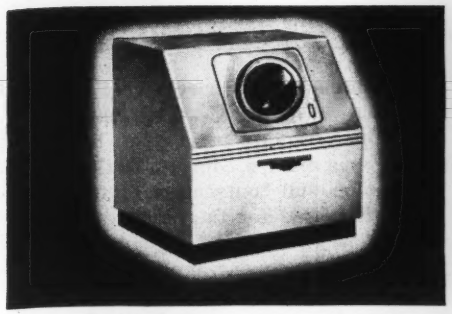
Design Abstracts

These include coke, lampblack, charcoal, artificial and natural graphites, to name only a few. The binder can be any hydrocarbon that has a high coking value. The proper ingredients are in themselves so different that a wide range of grades can be obtained, possessing an equally wide range of physical properties.

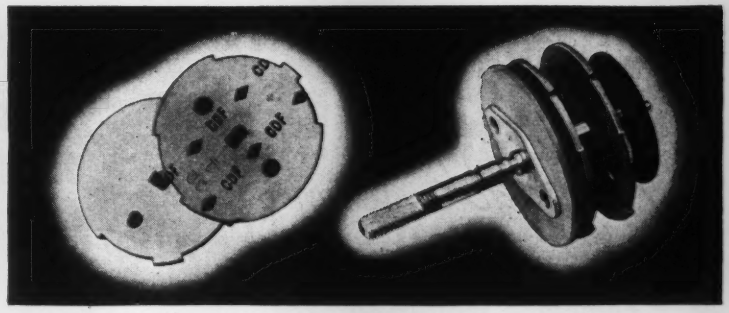
In the mixing of the carbon and graphite particles, with a hydrocarbon bond, it is absolutely necessary to attain a blend that is homogeneous. Following controlled mixing, the granular solid must be pulverized to a closely controlled micron specification that permits maximum compacting to a uniform density. By using individual dies, compacting pressures of from 20 to 30 tons per square inch briquette these powdered solids in much the same manner as that used in fabricating sintered-metal parts.

Following briquetting, the formed piece is furnaced in controlled atmosphere furnaces of several different types. The object is to carbonize or graphitize the hydrocarbon bond and thus realize an end product of carbon and graphite bonded with carbon and yet not open up the pore structure any more than is absolutely necessary. Subsequent impregnation in the binder and subsequent furnacing treatments can be repeated to carbonize more binder in the pores and thus partially close the pore structure. Seals that are nonporous at 1000 pounds per square inch water pressure at room temperatures are repeatedly achieved in production.

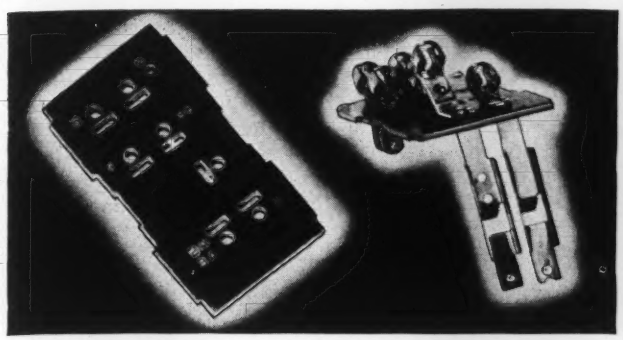
Disadvantages of Carbon-Graphite: Being brittle, carbon-graphite must be handled with care and designed to eliminate thin sections. Carbon-graphite is low in tensile strength. The material must be used under compression in almost all applications. Its coefficient of thermal expansion is low and this can often be a detriment in case it is applied as a high-temperature bearing. There is a four to one expansion differential between steel and carbon-graphite and hence on a high-temperature application, the shaft might expand at a greater rate and cause interference. A



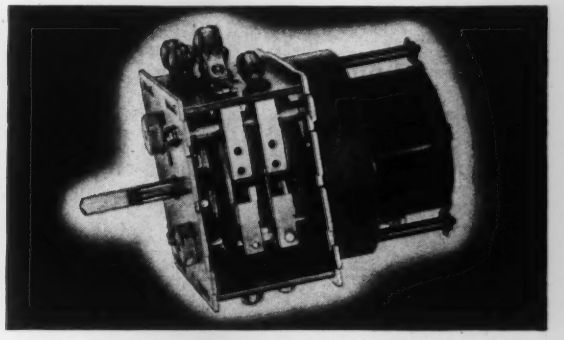
What makes the miracle of automatic washdays? What gadget turns water on and off; starts spinners, agitators, fans; regulates heat . . . all on a precise timing schedule? Chances are it's a P. R. Mallory timer switch.



Special paper-base Dilecto laminated phenolic cams are the heart of the switch. If the corners are not sharp, if tolerances are not held, if the laminated plastic fails, the timing schedule would go haywire. But it doesn't happen with Dilecto cams *fabricated by C-D-F*, now definitely identified for performance comparison.



C-D-F also supplies these Dilecto insulating side boards. Dilecto Grade X-13 was chosen for its ability to withstand severe riveting and staking impact, for its sturdiness in holding up under the strain of plugs being inserted and removed from terminals mounted on the board.



Look inside the smart, small, tough Mallory timer switch. The shaft revolves; with the switch operated by a manual clock which is wound or set whenever the switch is turned over to complete the entire cycle. *Switch accuracy depends entirely on the degree of accuracy in which the cam is manufactured.*

C-D-F and DILECTO® LAMINATED PLASTIC helped Mallory

improve design . . . simplify purchasing . . . speed production

Two C-D-F Dilecto laminated plastic parts play small but vital roles inside P. R. Mallory's timer switches used to control the washing, drying, rinsing cycles.

Most important, the timing cams must be precisely fabricated to odd, notched shapes, with very close dimensional tolerances. In the design stage, it was first thought that there was no practical way to obtain the desired pieces.

But engineering-supplier teamwork always pays off. Good basic design . . . a quality material from an alert, interested fabricator . . . selective purchasing resulted in a solution.

C-D-F WORKS WITH DESIGNERS

A father and son team, in Mallory's Switch Division, Arthur and Harry Hall, began 15 years ago to make this timer switch. Cam material after material was tested . . . none worked satisfactorily.

C-D-F sales engineer Robert Tappan was called in. He says, "After 18 months, the design was adaptable to Dilecto laminated plastic. The first cam did not work, but showed promise. Looking back, it was a crude punching compared to the ones now furnished by the C-D-F Valparaiso plant."

A BIG, RELIABLE SOURCE

Mallory makes thousands of timer switches, naturally has several suppliers for laminated plastic insulation. But C-D-F keeps working hard to further improve the product: Special tools have been designed to increase the accuracy of C-D-F cams, to provide Mallory with *lower rejection* rates. Resin-penetrating and laminating techniques have improved Dilecto grades. Inspection and quality control have been modernized.

When you have a problem in laminated plastics, think of improved, Dilecto and C-D-F. Send us your print for technical advice and quotation. Write for free test samples. The C-D-F catalog is in Sweet's Design File and the IRE Directory. Best of all, call your C-D-F sales engineer . . . He's a good man to know!

CDF *Continental-Diamond Fibre*

CONTINENTAL-DIAMOND FIBRE COMPANY

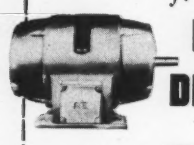
NEWARK 23 DELAWARE

exclusive

REULAND

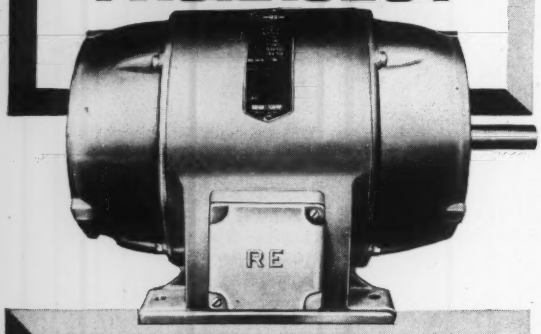
"Xpandable" design

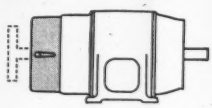
typical adaptations from this



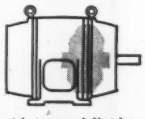
BASIC DESIGN

combines motors • brakes fluid couplings • gear-reducers into tailor-made single-unit POWER PACKAGES!

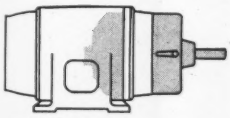




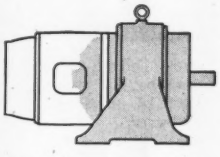
Motor with Reuland "Through Shaft" magnetic brake



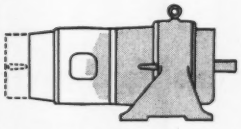
Motor with internal fluid coupling



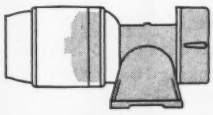
Motor with fluid coupling and brake on output shaft



Motor with fluid coupling and helical gear reducer



Motor with fluid coupling, output shaft brake and helical gear reducer (second brake may also be added)



Motor with fluid coupling, right-angle worm reducer and brake

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Design Abstracts

simple way to circumvent this disadvantage is to shrink fit the carbon-graphite in a metal band and thus make it conform to the expansion and contraction of the material used for the backing member. Size limitations can only be overcome by using multiples in series or by sectioning rings. Butt joint piston rings of 20-inch diameters and metal-backed cylinder liners made in multiples are examples of this type.

Advantages of Carbon-Graphite: The advantages of carbon-graphite are an inherent high hardness of 100 Scleroscope "C", approximately the equivalent of 65 Rockwell "C". Carbon-graphite is quite light, weighing about one ounce per cubic inch, and has a density of 1.7. Its dimensional stability is remarkable. Carbon-graphite sublimes at about 6300 F and has a compressive strength in some grades of approximately 35,000 pounds per square inch. From a chemical standpoint, it is corrosion-resistant to almost all organic compounds and is not affected by a wide range of inorganic chemicals. It may be used in pure oxygen below 400 F and in a neutral or reducing atmosphere at extremely high temperatures and still retain its strength. From strictly a mechanical stand point, it will not handle harsh abrasives. It is good in fretting corrosion and has high wearing characteristics.

Applications of Carbon-Graphite: Perhaps the best known application for this material is in the field of face-type rubbing seals—particularly those involving high speed, high temperature, high pressure, or a combination of these three conditions.

In sealing a wide variety of fluids ranging from dry air to trichlorethylene to water, the fluid being sealed will act as the seal lubricant and coolant. A grade should be used containing enough porosity to permit boundary lubrication without permitting leakage. Due to the uniformly dispersed voids that are almost capillary in size, this can be attained, for here we have a material with a pore structure

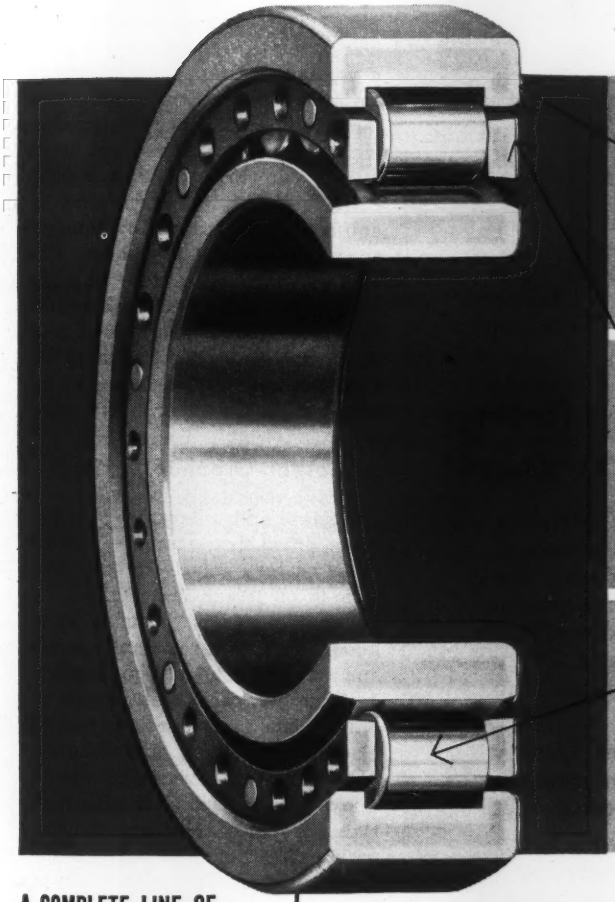
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



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● ***COMPOSITE STEEL CAGE DOES NOT CONTACT ROLLERS DURING NORMAL OPERATION,*** thereby allowing free movement of the rollers between the races. Projections on the inner faces of the rings engage indentations on the roller ends preventing the rollers from dropping out of position when the separable race is removed.

● ***PRECISION-BUILT ROLLERS AND RACES ARE MADE TO SUPPORT MAXIMUM RADIAL LOADS.*** Only the highest grade steel-alloy is used, and rollers and races are precision ground to give quieter, smoother operation. Running clearance is built in at the time of manufacture.

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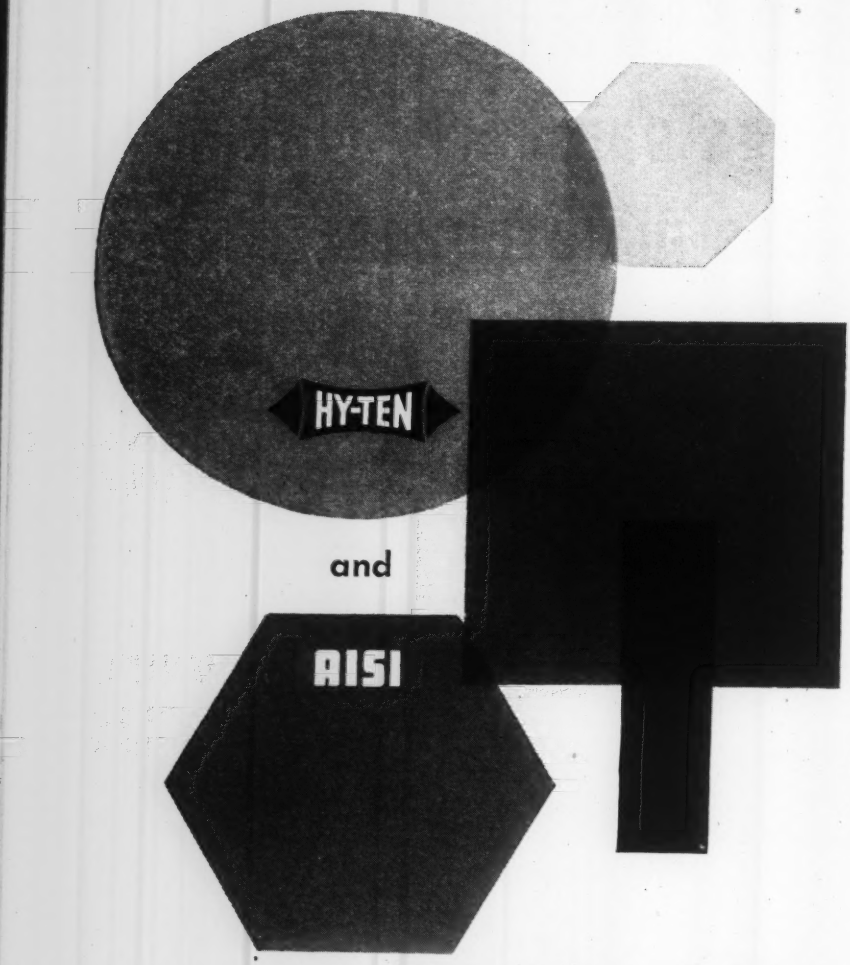
BOWER

ROLLER BEARINGS

SPHER-O-HONED



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similar to that attained in powdered metals, only the pores are much smaller in size. The nonmelting quality of carbon-graphite, its high surface hardness and its ability to be lapped flat and stay flat, are the key points on why this material is so widely used on these applications to date. Special seal designs have been made to handle dry air at 500 F temperatures, 100 psi pressures and 200 feet per second velocities. Seal life with gases or liquids not containing abrasive solids is in the order of 20,000 hours on a number of normal applications.

Quite a bit of latitude can be used in seal designs in regard to most all tolerances including lapping. The conformability of carbon-graphite is excellent and hence a commercial lap is often just as satisfactory as a three light band lapping specification. Material selection on the other hand is extremely important. Heavy lubricating oils and greases that are subject to breakdown by temperature present quite a problem. Conversely, carbon-graphite will give excellent performance as a bearing or a seal when used at 250 to 500 F with top quality nongumming oils. Probably the best lubricant for carbon-graphite is clear, pure water.

Carbon-Graphite Bearings

Design and tolerance specifications on carbon-graphite bearings must be very good. Material selection is of lesser importance. Carbon-graphite must be used with a good corrosion-resistant mating surface on hot, dry applications. Incipient surface rusting will not only cause high friction, but will also promote high wear. Bronze, aluminum and even zinc die-cast alloys can be used as mating materials, provided they are machined with a good, smooth surface.

How, when and where to use carbon-graphite as an engineering material depends to a large extent on the design in which it is used. High quality, close grained, carbon-graphite can only be made in limited sizes. And yet, as an engineering material, it possesses the basic qualities needed to meet many

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says Service Caster & Truck Corporation "The WEBSTER Hydraulic Pump has been very satisfactory. It is easy to install because the drive gear is an integral part of the pump drive shaft. This is an economy feature; we save time installing the unit, and eliminate the problems of a keyed assembly.

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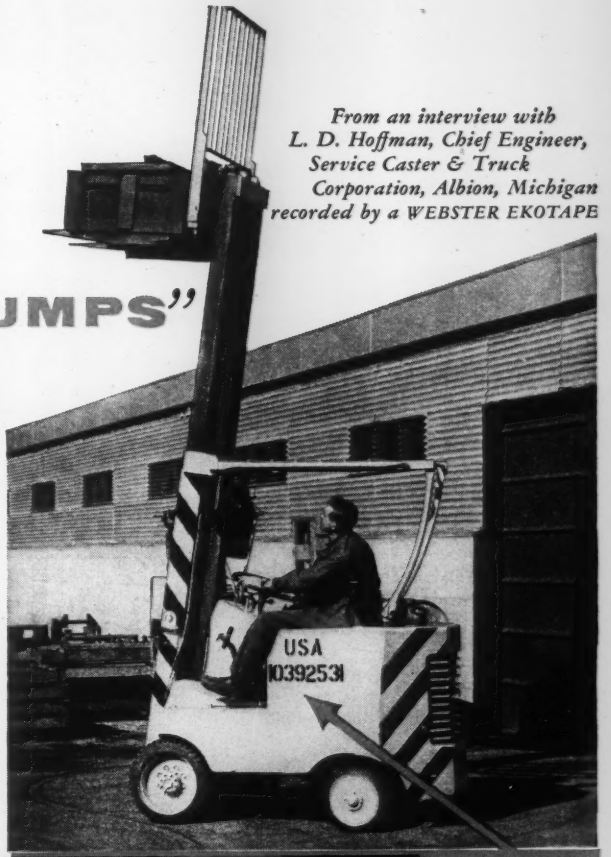
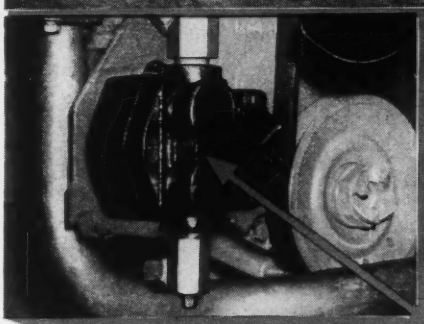
"This WEBSTER Hydraulic Pump compares favorably with the pumps that we've used previously . . . and saves us money two ways."

From an interview with L. D. Hoffman, Chief Engineer, Service Caster & Truck Corporation, Albion, Michigan recorded by a WEBSTER EKOTAPE





S4024 4000-lb. fork lift truck, made to U. S. Navy specifications for the Army by Service Caster & Truck Corp., is equipped with a WEBSTER Hydraulic Pump

Here you see how the type HC WEBSTER pump is attached for direct drive from engine of Service Caster-built fork lift truck

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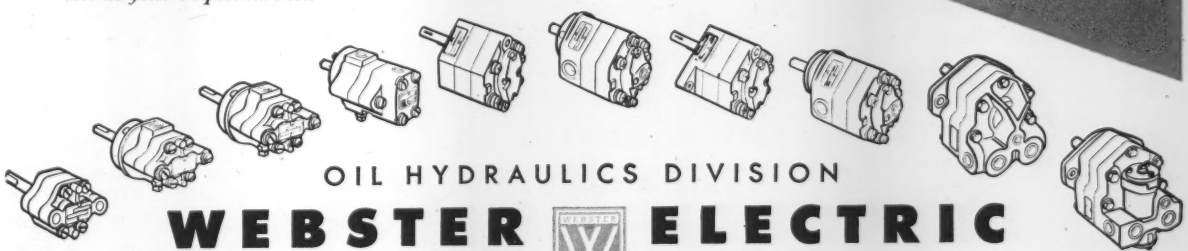

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Design Abstracts

up-to-date design problems. Problems involving high temperature, high speed, and high pressure and problems involving clean gases and liquids can often be solved by using carbon-graphite.

From an address entitled "How, When and Where to Use Non-Metallic Materials—Carbon-Graphite" presented at the second Basic Materials Conference in Chicago, Ill., May, 1954.

Evaluation of Precision Casting Techniques

By L. M. Christensen

Castings Design Consultant
Northrop Aircraft Inc.
Hawthorne, Calif.

THE age old and still basic casting process is that of using sand as the molding medium. From that start have evolved the several variations of so called precision type castings, and the major ones included in this classification are permanent mold, die casting, shell molding and precision investment. In discussing the precision types we sometimes tend to disregard sand castings and this can be a serious error.

Sand Casting: In discussing sand castings as a precision form of casting fabrication, it can definitely be stated that under certain circumstances sand cast parts can be made as accurately, and with as smooth a quality surface, as permanent mold castings. One big advantage to be gained by going to precision sand castings, when conditions are right, is the fact that mold and preparatory changes will be less, even when obtaining a so-called high precision type. Other factors not to be overlooked in close-tolerance sand casting are several inherent basic advantages other than cheapest cost for low quantities. One of the biggest is the fact that a sand casting can be successfully made more complicated than any other form of casting, particularly in the larger sizes. Another is that rework to size of patterns, after casting check samples, is more

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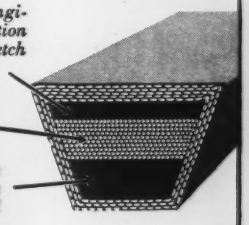

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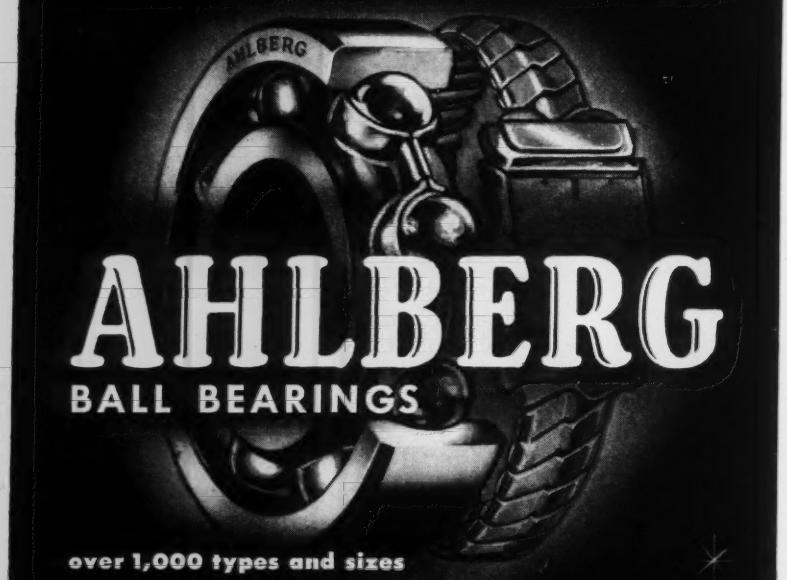

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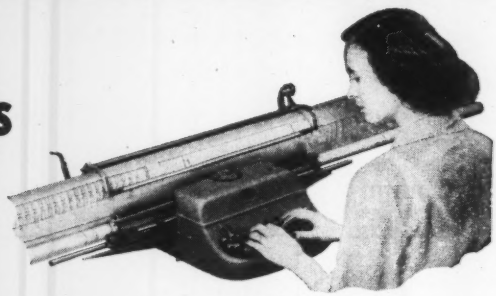

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easily and more economically accomplished with patterns than with other forms of master or mold equipment. Gating changes on sand cast pattern equipment are certainly more easily accomplished than the other forms, and this can be no mean item, because regating is so often necessary in order to clean up internal X-ray defects.

Permanent Mold Casting: Permanent mold and die casting are hardly brand new casting techniques, as can more truly be said of shell and precision investment but it is well to remember some of their good and bad features. Permanent molding is essentially a high production, but rather inflexible process. Any rules to govern the quantity at which it would be economically feasible to convert from sand casting to permanent mold, would naturally have to be flexible because of the drastic effect of the individual design. Where machining is eliminated on the permanent mold casting to a greater extent than could be accomplished with a sand casting, the cross-over point at which the permanent mold would become cheaper may be a low figure such as 50 to 100 parts. However, for the general run of designs, this economical point is likely to be in the neighborhood of 1000 units.

It requires quite a degree of experimentation to work out the difficulties in gating from an X-ray standpoint. The design cannot be so complicated as to force the mold maker to incorporate at least a portion of his mold into sand cores, instead of being able to stay with more accurately controlled metal segments. The designer has to be much more careful in his setting up of the basic shape, if he expects the mold to yield a part which will be relatively free from internal defects. To be more specific, all gating and risering just about has to be located on the parting line of a permanent mold. This means that gating and risering can be attached or brought into the cast shape only around the edges. If the design has a heavy boss in the center of a thin web, and the parting line cannot bisect

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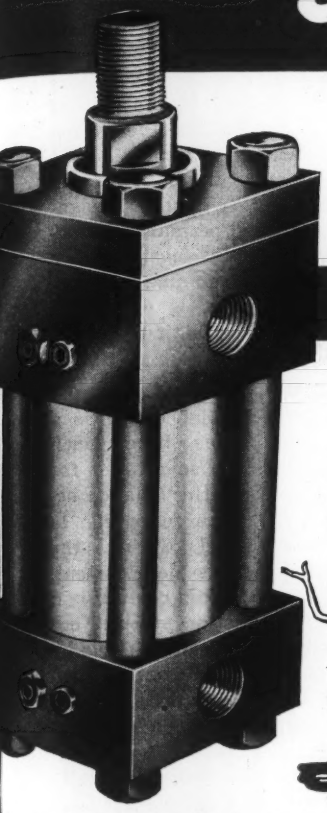

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						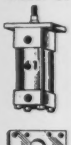	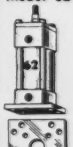	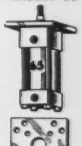	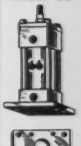	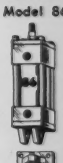
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1½"	6"	Non		62.90		65.80		71.10		77.25
1½"	8"	Non		65.10		68.00		73.30		79.45
1½"	11"	Non		68.40		71.30		76.60		82.75
2"	2"	Non	$ 37.70		$ 39.75		$ 42.30		$ 44.60	
2"	4"	Non	39.40		41.45		44.00		46.30	
2"	6"	Non	41.10		43.15		45.70		48.00	
2"	8"	Non	42.80		44.85		47.40		49.70	
2"	11"	Non	45.35		47.40		49.95		52.25	
2"	3"	Both	62.05	94.50	64.10	97.45	66.65	103.05	68.95	111.55
2"	5"	Both	63.75	97.00	65.80	99.95	68.35	105.55	70.65	114.05
2"	7"	Both	65.45	99.50	67.50	102.45	70.05	108.05	72.35	116.55
2"	9"	Both	67.15	102.00	69.20	104.95	71.75	110.55	74.05	119.05
2"	13"	Both	70.55	107.00	72.60	109.95	75.15	115.55	77.45	124.05
2½"	2"	Non	41.45	73.30	43.70	76.25	46.25	82.30	49.00	93.10
2½"	4"	Non	43.35	76.00	45.60	78.95	48.15	85.00	50.90	95.80
2½"	6"	Non	45.25	78.70	47.50	81.65	50.05	87.70	52.80	98.50
2½"	8"	Non	47.15	81.40	49.40	84.35	51.95	90.40	54.70	101.20
2½"	11"	Non	50.00	85.45	52.25	88.40	54.80	94.45	57.55	105.25
3¼"	3"	Both	77.80	126.85	80.35	131.20	84.15	138.60	87.70	149.95
3¼"	5"	Both	79.80	129.85	82.35	134.20	86.15	141.60	89.70	152.95
3¼"	7"	Both	81.80	132.85	84.35	137.20	88 15	144.60	91.70	155.95
3¼"	9"	Both	83.80	135.85	86.35	140.20	90.15	147.60	93.70	158.95
3¼"	13"	Both	87.80	141.85	90.35	146.20	94.15	153.60	97.70	164.95
4"	2"	Non	56.25	106.00	59.10	111.15	62.95	118.90	67.30	132.80
4"	4"	Non	58.85	109.40	61.70	114.55	65.55	122.30	69.90	136.20
4"	6"	Non	61.45	112.80	64.30	117.95	68.15	125.70	72.50	139.60
4"	8"	Non	64.05	116.20	66.90	121.35	70.75	129.10	75.10	143.00
4"	11"	Non	67.95	121.30	70.80	126.45	74.65	134.20	79.00	148.10
5"	3"	Both	98.25		101.40		105.25		110.60	
5"	5"	Both	101.65		104.80		108.65		114.00	
5"	7"	Both	105.05		108.20		112.05		117.40	
5"	9"	Both	108.45		111.60		115.45		120.80	
5"	13"	Both	115.25		118 40		122.25		127.60	
6"	2"	Non	80.60		83.95		87.85		94.15	
6"	4"	Non	84.90		88.25		92.15		98.45	
6"	6"	Non	89.20		92.55		96.45		102.75	
6"	8"	Non	93.50		96.85		100.75		107.05	
6"	11"	Non	99.95		103.30		107.20		113.50	
8"	3"	Both	157.35		161.05		167.90		174.95	
8"	5"	Both	162.45		166.15		173.00		180.05	
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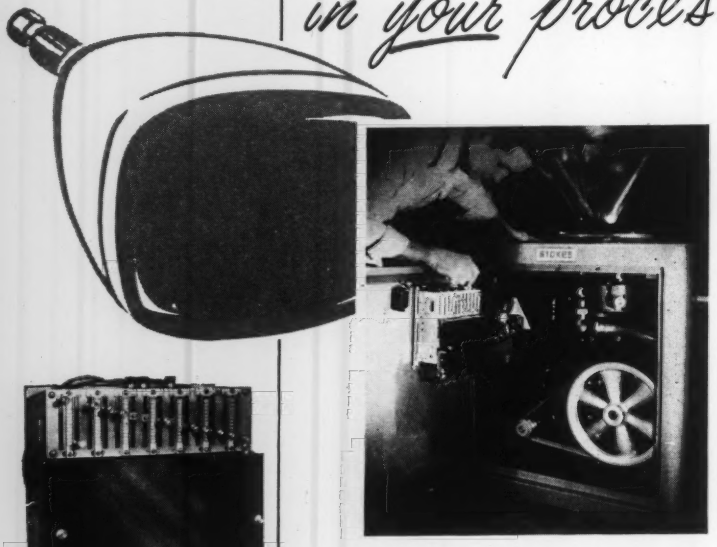

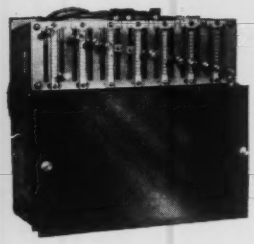

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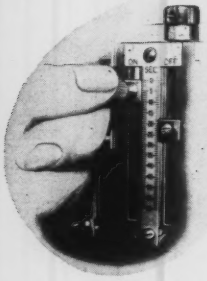

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Design Abstracts

it to allow molten metal to be available at the last stages of freezing, then poor quality castings are likely to result.

Permanent molding of certain types of designs has been enhanced recently by a rather thorough production adaptation of centrifugal action for the refinement of grain structure, better filling of molds, closer tolerances and higher surface quality. Designing to centrifugal permanent molding is economically feasible when quite a bit of machining, or very difficult machining, is eliminated to offset a rather high mold and per piece cost.

Die Casting: Die casting is a process which has been much maligned at times, some of it for good reasons and the balance because of groundless fears due to experiences gained during the early stages of its development. Most people know die casting is a good high production process, but will authorize parts to be made by this rapid method only when strength is of almost no consequence. It is a common comment that die castings are usually highly accurate and beautifully smooth on the outside, but also called "piece of cheese" on the inside. This is not necessarily true, and particularly if the sectional thicknesses are approximately 3/16, or less. A high quality die casting, called pressure molding, was developed during the last war for the express purpose of obtaining good quality die castings for structural use in aircraft. This was accomplished and the outcome of it today is a high strength, fairly dependable product which has found considerable favor among many of the various aircraft companies.

An estimate of the average quantity required to make a die casting pay off over other methods of manufacture will usually be in the range of a couple of thousand parts. Precision, good surface quality and thin webs can be easily achieved in a die casting machine. As in other casting processes, where the ultimate in precision is demanded, the die

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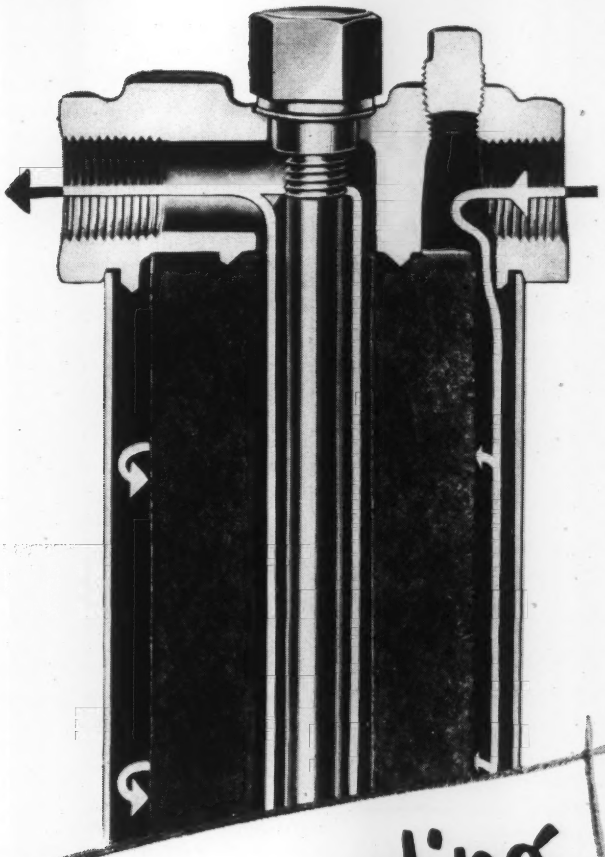

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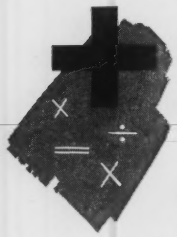

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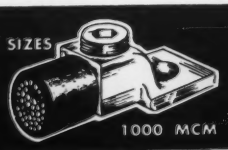
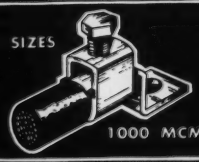


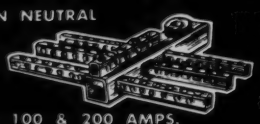
1000 MCM — 14

SLU 11 SIZES



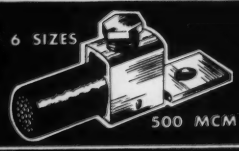
1000 MCM — 14

CAN NEUTRAL



60, 100 & 200 AMPS.

XT 6 SIZES

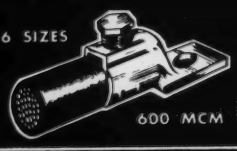


500 MCM — 14

FUSE CLIPS

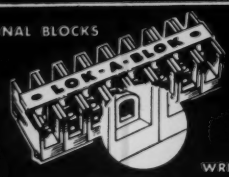
MANY SIZES AND TYPES

VT 6 SIZES



600 MCM — 14

TERMINAL BLOCKS



MU 3 SIZES

500 MCM — 6

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caster will make the die on the underside, and then after die tryout, to prove out shrinkage, etc., will rework the critical dimensions to their final configurations. Due to the fact that the cycles per hour on the average die casting machine are quite high and usually a multiple cavity mold can be utilized, the actual output of castings on an hourly basis will be considered as good. Also, not everyone realizes that die castings of larger sizes can, and often should, be made for relatively high quantities.

Often die castings are thought of in terms of zinc or so-called pot metal; however, the light alloys, aluminum in particular, have made big inroads into die-casting industry, particularly for applications in the field of portable equipment. One advantage which the die-casting process holds over any other form of casting is the matter of heat treatment. It is the only method which obtains its full physical property values without the necessity of going through regular heat treatment.

This is accomplished by the rapid chill obtained in the metallic die, thus achieving the same result as is gained in the other cases with the reheat and fast quench from solution temperatures. The biggest benefit from the elimination of solution heat treatment is that there will be no warpage from strains set up by the quenching sequence.

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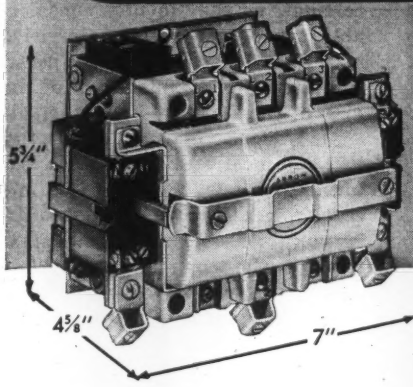
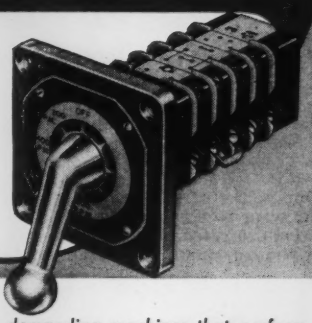


SIZE 2 STARTER



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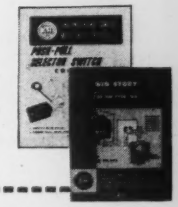

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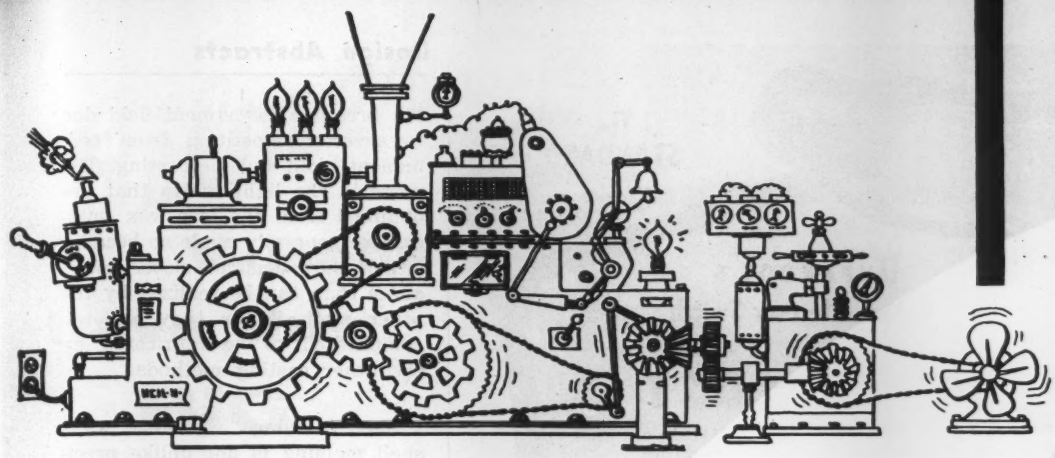
signing to precision investment is that it is basically an expensive process. Fortunately there are variations of making the tooling so that for low quantities (10 to 200 parts) the tooling can be fabricated from relatively cheap tin bismuth type alloys. For higher production quantities, aluminum or steel dies are utilized to form the wax, plastic or frozen mercury patterns. There is no particular short cut, however, to making the castings, as they involve considerable labor and rather expensive materials to make up the parts. Perhaps a little explanation of the uses of the three mediums for patterns would be in order. The original and most common pattern material which is, more or less, die cast from the above mentioned die is wax; consequently, the derivation of the common term "lost wax" since wax is volatilized from the inside of the plaster mold to set up the cavity. On occasion, polystyrene plastic will be used in place of wax, largely because it is more stable. For the same reason the plastic is then sometimes supplanted by frozen mercury as being the ultimate in gaining an inert pattern.

Quite understandably, each pattern material will be more expensive than its predecessor. Since the per piece price is going to be relatively high, it will obviously be necessary to either save quite a bit of machining or a small amount of rather intricate machining. If this can be done, but for one reason or another cannot be done by the other casting process, then the part should be of precision investment fabrication.

Casting Alloys

Until the recent advent of shell molding, precision investment had no other competitive casting process in the heat resisting alloys when precision was required. The lost wax process still retains top billing when it comes to the order of ability to hold tolerances. A tolerance of plus or minus 4 or 5 thousandths is not uncommon among the smaller designs. Applications of aluminum and magnesium are much more uncommon in



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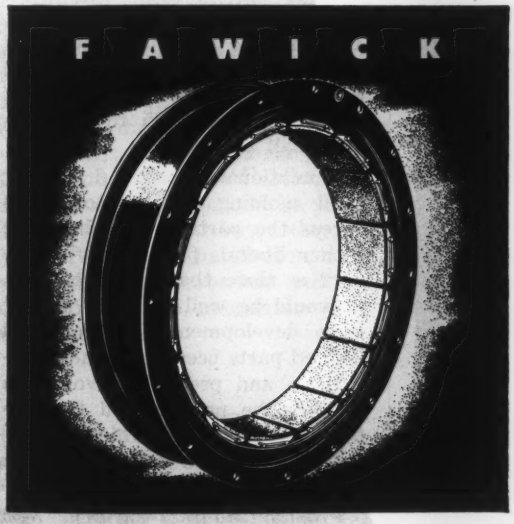

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Design Abstracts

the precision investment field due to severe competition from permanent mold and die casting. The parts in the light alloys that are obtained from the lost wax process are generally made so because either they demand closer tolerances than can be realized by the other methods, or they are too complicated to be fabricated by the other casting methods.

Shell Molding: In some ways shell molding is not unlike precision investment; as a matter of fact, it is sort of a hybrid combination of lost wax and sand casting. Its similarity to sand casting is that sand is actually used in the make up of the molds and the pattern equipment is of a related nature to the match plates used in the average foundry. Its coincidence with the lost wax type operation is mainly in that it derives a smooth surfaced close tolerance part from a mold of durable composition. Shell molding, like precision investment, is not likely to find any great amount of application in the light alloy field, largely due to competition with permanent mold and die castings. It will find a very definite niche, however, as a sort of precision sand casting in the ferrous alloys. The tolerances and surface quality of shell molding, although a cut lower than precision investment, are none the less quite good with a surface of comparable to 200 RMS and a general tolerance of plus or minus 0.005 to 0.01-inch for small dimensions.

A cautionary note in design for shell molding is that tolerances across the parting line should be rather liberal, particularly if the part is more than 6 inches long. It would be well to allow a little extra development time for shell molded parts because of the greater care and precision involved in making the pattern and the pattern tryout period, which is likely to be a little longer than the usual.

From an address entitled "New Casting Techniques — Precision Castings" delivered at the second Basic Materials Conference in Chicago, Ill., May, 1954.

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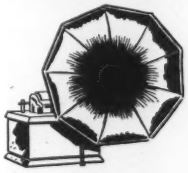

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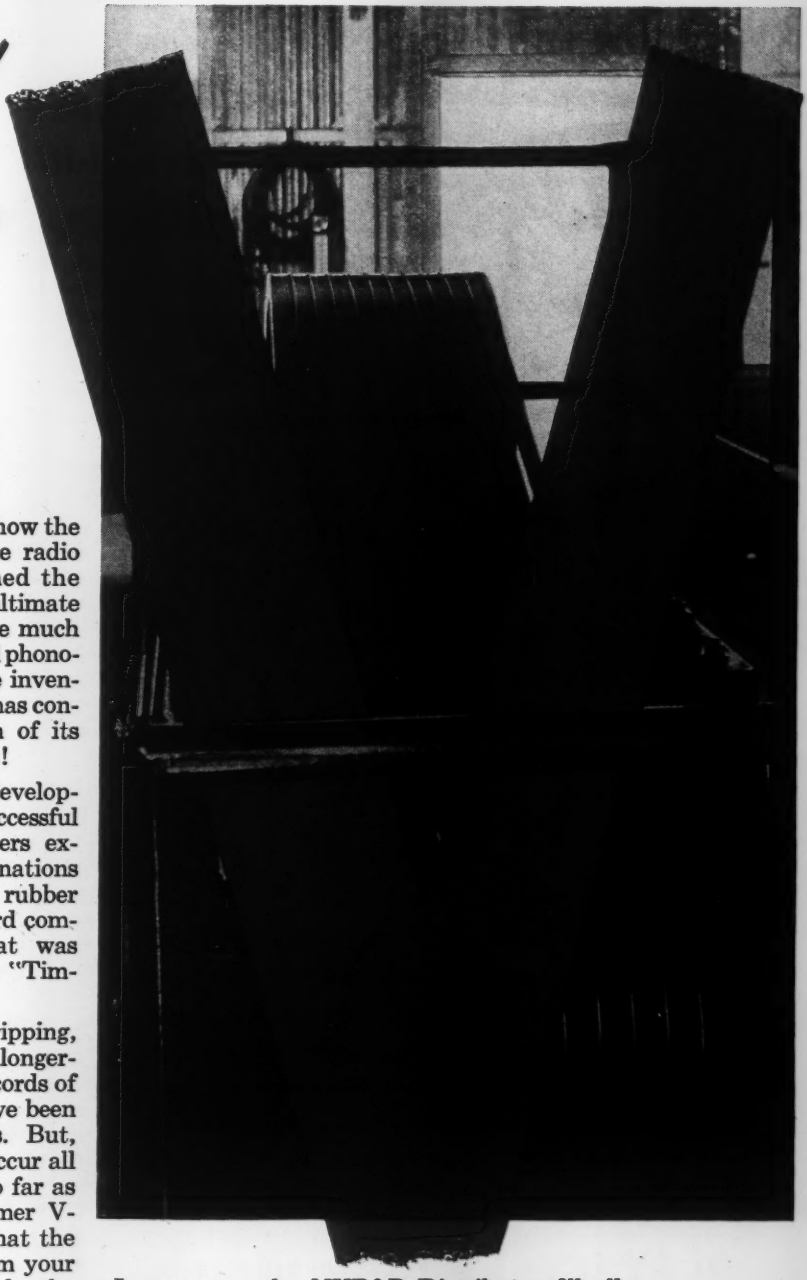

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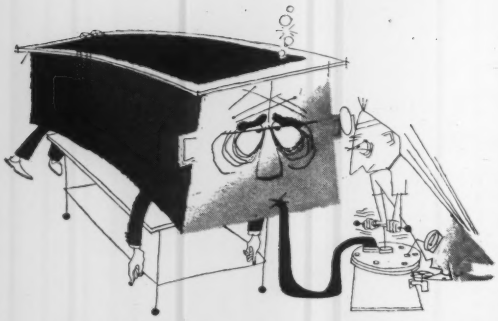

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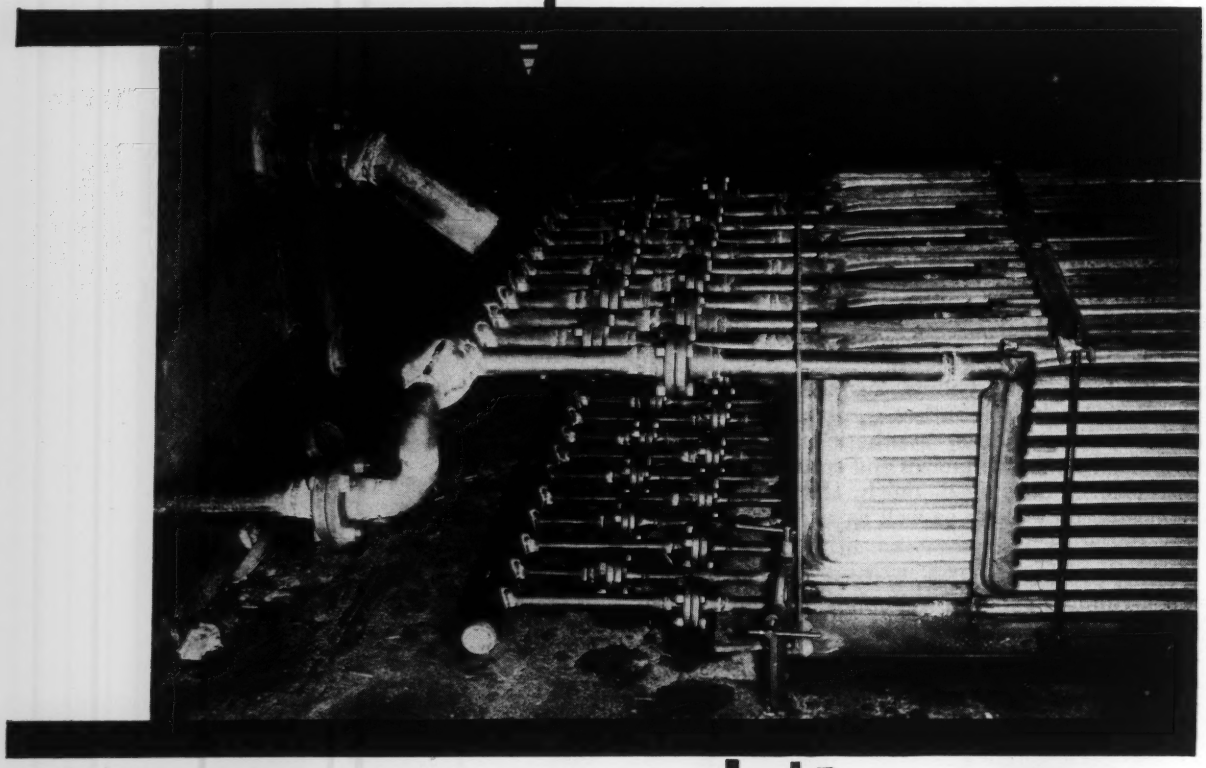

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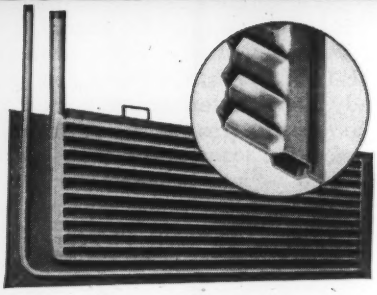

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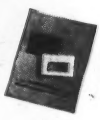

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David W. R. Morgan

this year. A member of ASME since 1936, Mr. Morgan has been associated with Westinghouse since 1913 in various assignments connected with power generating equipment. He holds more than 30 patents relating to condenser, heat exchanger and diesel engine apparatus. From 1925 to 1927 he was a member of the American Standards Association's Hoover Committee on Standardization. A graduate of Ohio Northern University, Mr. Morgan has received an honorary degree of Doctor of Engineering from Drexel Institute of Technology.

E. W. Theilig, former product engineer at the Harrison, N. J., plant of Worthington Corp., has

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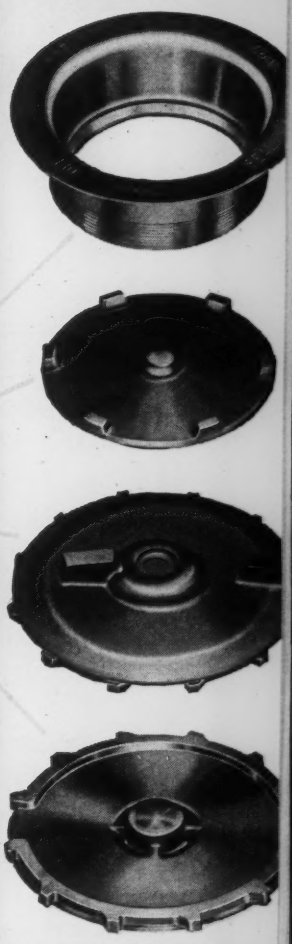

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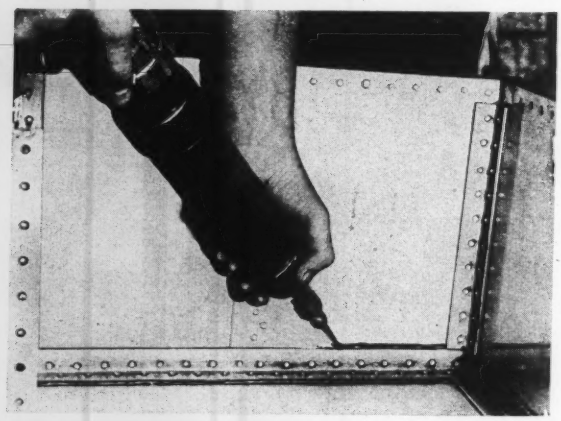

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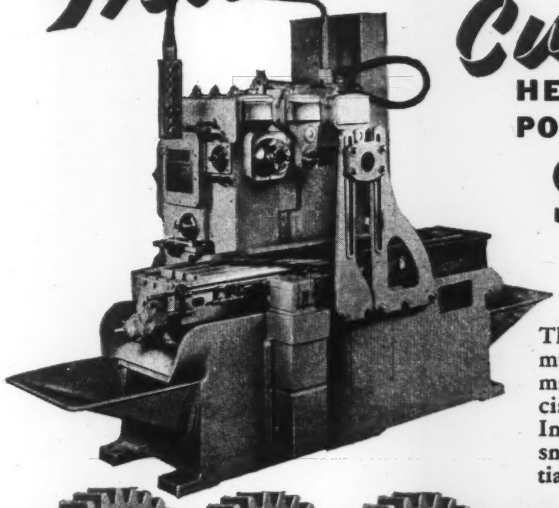
Men of Machines

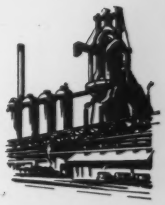
been appointed chief engineer of the Power Pump Engineering Department with headquarters at the Oil City, Pa., works. Mr. Theilig joined the company's Holyoke Works in 1917 as an apprentice in the drafting department, then served successively as detailer, junior designer and designer. In 1932, when the Holyoke Works operation was transferred to Harrison, he was appointed design engineer. Prior to his new appointment, he was product engineer on all large horizontal power pumps and large vertical multicylinder pumps. Mr. Theilig is the author of the article, "Synochronized Load Control," which appeared in the December 1953 issue of MACHINE DESIGN.

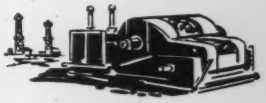
Former manager of the General Engineering Laboratories of American Machine & Foundry Co. in Greenwich, Conn., **R. A. Kimes** has been named director of engineering of the company's Electronics Div. in Boston. Mr. Kimes has served as manager of the laboratories since their establishment in June 1953 and before that was manager and assistant manager of the Special Products Department of the Engineering Div. He joined the company in 1946 as assistant to the works manager of the Buffalo plant. He is a graduate of Drexel Institute of Technology and

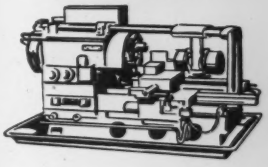
R. A. Kimes

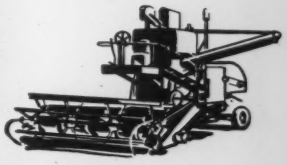
Industrial Cut Gears









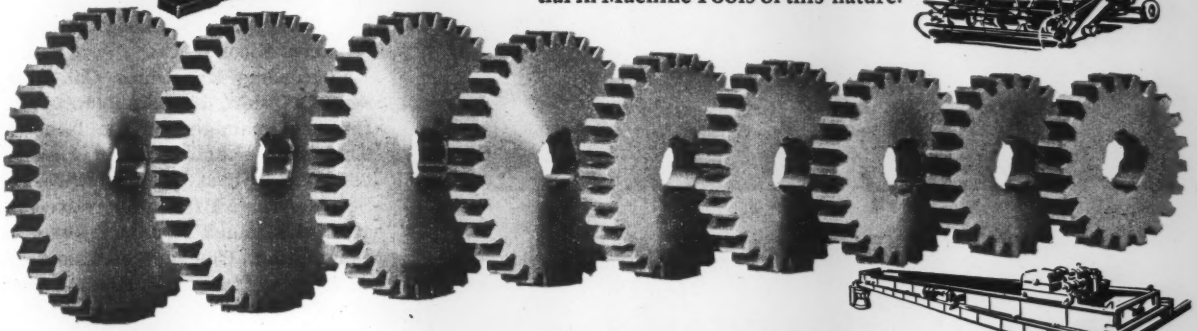


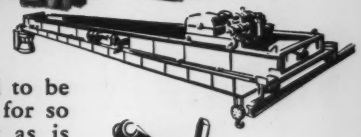
HELP TRANSMIT THE POWER THAT ENABLES

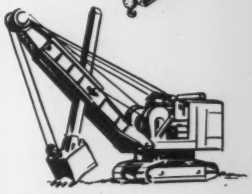
Sundstrand

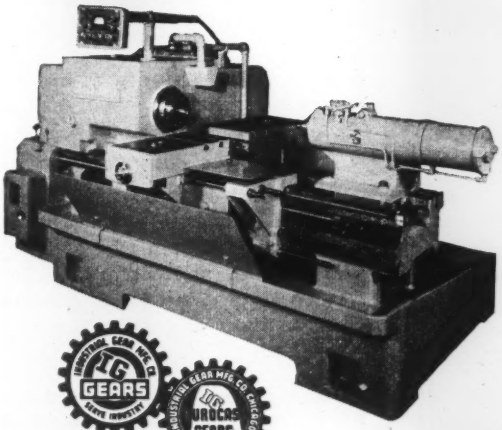
MILLS and LATHES TO FUNCTION

The 'Nth degree of accuracy, is a must here. And, as these Sundstrand machines assure the highest precision in milling and turning so do Industrial Cut Gears provide for the smooth operation that is so essential in Machine Tools of this nature.





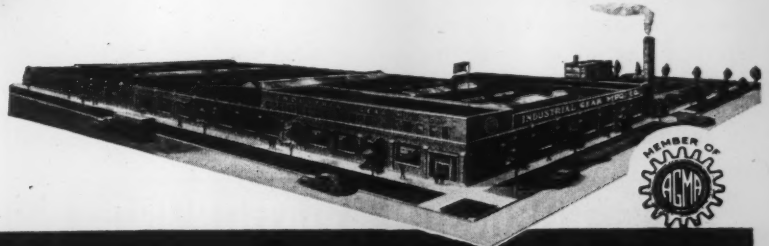




We are proud at Industrial to be factors in supplying Gears for so highly exacting equipment as is pictured here. It proves the worthiness of our product and the reliance users place upon us to meet their demands.

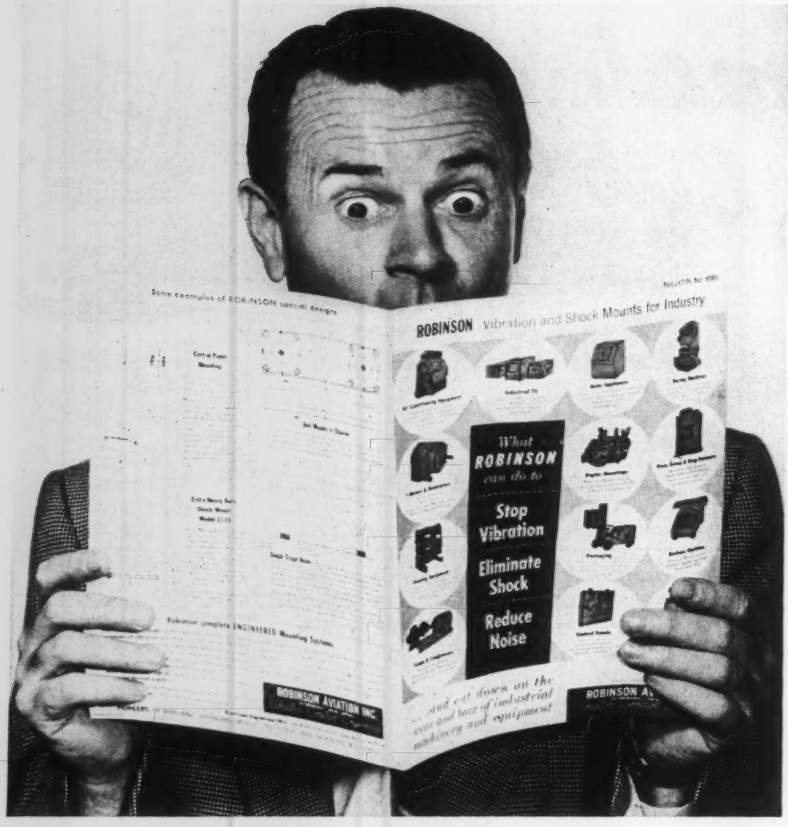
"IG Durocase" (Steel Mill type Gears) and "IG General Service" Gears are ready to serve you too.

May we have the opportunity to work with you?



Our plant, devoted exclusively to gear and sprocket cutting, can be visited pictorially through Bulletin No. 152-A. Write for your copy—and see how well equipped we are to handle your needs.

Industrial Gear Mfg. Co. 4529 W. 7th BUREN ST. CHICAGO 24, ILLINOIS



Your eyes will open, too, at this new concept of

VIBRATION and SHOCK CONTROL

First to recognize the advantages of all metal mounting systems, Robinson launched an entirely new concept of vibration and shock control. This new concept offers the answer to many of today's unusual and exacting engineering problems.

Outstanding feature of Robinson systems is the employment of resilient load-carrying cushions of metal wire (Met-L-Flex). These metal cushions are actually knitted so as to form a multiplicity of interlocking springs continuous from top to bottom. The result is that mounted equipment literally floats on a cushion of thousands of tiny springs. Performance is unaffected by grease, oil, water, dust or extreme temperatures. Inherent high damping assures complete control of shock and vibration at all times.

Highest standards of performance proven by years of severe testing in military installations, the Robinson concept is now available in industrial fields.

Send for free booklet

For full information about this new concept of vibration control, whether your problem involves delicate instruments or heavy machinery, send for booklet 850. Write or wire today. Industrial Division Dept. MD3.

ROBINSON AVIATION INC.
TETERBORO, NEW JERSEY
Vibration Control Engineers

Men of Machines

Horace A. Quinn

was previously associated with Western Electric Co.

Succeeding Mr. Kimes, **Col. Horace A. Quinn,** U. S. A. (Ret.), is the new manager of the General Enginering Laboratories. Having served 23 years with the United States Army, Mr. Quinn retired in 1946 and joined Armour Research Foundation, Chicago, as assistant director of research. His military service included ten years in the research and development of aircraft weapons. A graduate of the United States Military Academy, he received an M.S. degree in 1934 from Massachusetts Institute of Technology.

R. A. Carlson is now vice president and manger of engineering of the Rockford Clutch Div. of Borg-Warner Corp. at Rockford, Ill. His former duties included those of chief engineer of the division.

Mark J. Garlick has been appointed assistant chief engineer of the Pontiac Motor Div. of General Motors Corp., Pontiac, Mich. He succeeds **R. R. Hutchison,** who has retired. Mr. Garlick joined the Oakland Motor Car Co., predecessor to the Pontiac division, in 1928, after receiving a B.S. degree in mechanical engineering from the University of Michigan. In 1931 he was transferred to the technical data section of Pontiac

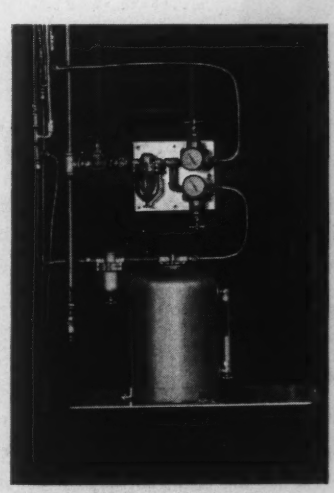
Norgren Spray-Lube System

DOUBLES OUTPUT OF VERTICAL TURRET LATHE at O. K. RUBBER, INC.

4 Spray-Lube lines give full spray coverage over 14¼" cutting edge of tool.

On roughing and finishing a straight ribbon tread on cast aluminum tire capping mold, Norgren Spray-Lube:

- stepped up surface cutting speed from 45 to 75 rpm.
- increased depth of cut.
- eliminated welding of chips on cutting tool.
- ended galling of work pieces.
- reduced tool maintenance.
- improved quality of work.

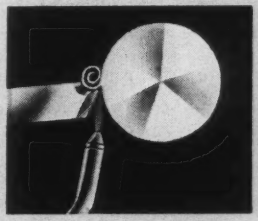


Spray-Lube control panel and liquid reservoir are centrally located for several machines.

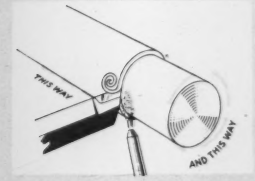
WRITE FOR COMPLETE DATA NORGREN BLUEPRINT SL-2

C. A. Norgren CO.
3442 So. Elati, Englewood, Colo.

PIONEER AND LEADER IN OIL-FOG LUBRICATION FOR 26 YEARS



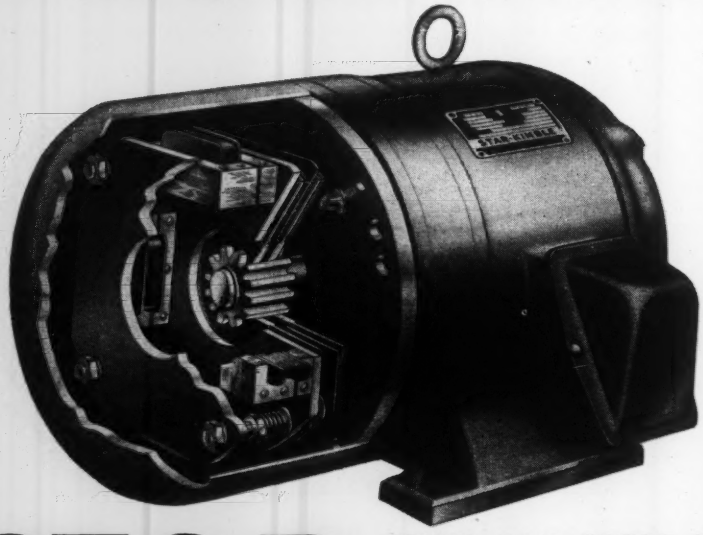
Coolant where you need it ... spray is applied to work area from any required direction to thoroughly lubricate critical contact areas between cutting tool and work piece.



Step Up Production Speed. Rapid cooling at the cutting point will enable you to increase both the speed, and the feed of the cutting tool, and still improve workmanship and tool life. Notable increases in machine output have resulted.

VALVES FILTERS HOSE ASSEMBLIES REGULATORS LUBRICATORS

START QUICKLY, SMOOTHLY, without BRAKE DRAG!



STOP FROM FULL SPEED IN A SPLIT SECOND!

WITH STAR-KIMBLE BRAKEMOTORS

Time from full speed to standstill can be as short as *one-fifth of a second* with a Star-Kimble Brakemotor — the *extra-large* brakelining area makes possible these *extra-fast* stops of motor and connected load.

Starting of the motor is fast and smooth, too. The small air gap results in instantaneous release of the brake when the motor current is switched on. No brake drag to impede acceleration.

These cycles of split-second stops and smooth starts can be repeated millions of times — that's proved by the experience of user after user of Star-Kimble motors, even in the severest types of service. In reversing service, a Brakemotor can make four times as many starts a minute as a motor which is reversed by plugging.

Every Star-Kimble Brakemotor is an integral, space-saving unit — with motor and brake designed and built together to work together. A single manufacturer — undivided responsibility.

For the full story, write for Bulletin B-501-A

STAR-KIMBLE

MOTOR DIVISION OF

MIEHLE PRINTING PRESS AND MFG. CO.

201 Bloomfield Ave. Bloomfield, N. J.

Men of Machines

engineering and advanced to development engineer in 1937. He became project engineer five years later and in 1950 was promoted to experimental engineer, the position he held until his new appointment.

F. A. Gruetjen was recently named director of aeronautical development at A. O. Smith Corp., Milwaukee.

Formerly chief engineer, **Howard C. Filbert** has been elected vice president of Miller Metal Products Inc., Baltimore, in charge of the Engineering Research Div. Mr. Filbert received B.S., M.S. and M.E. degrees from the University of Maryland and was associated with the Naval Ordnance Laboratory, Silver Spring, Md., for 11 years prior to joining Miller.

I. Nevin Palley has joined Temco Aircraft Corp., Dallas, Tex., in the newly created post of vice president of engineering. He will have complete responsibility for all engineering and electronic activities. Mr. Palley received a B.S. degree from Carnegie Institute of Technology in 1937 and joined Lockheed Aircraft Corp. as an aerodynamicist. He was subsequently associated with aircraft design at North American Aviation

I. Nevin Palley

Eastern Mixers lick the Tough problems . . .

EASTERN INDUSTRIES MIXER DIVISION

EASTERN INDUSTRIES MIXER DIVISION

Electrol Hand Pumps for Uniform 2-Way Pumping Action

The Electrol 525 Hand Pump has a volumetric capacity of 1.5 cu. in. per cycle.

The Electrol 770 Hand Pump has a volumetric capacity of of 2 cu. in. per cycle.

Electrol Double-Acting Hand Pumps are capable of delivering uniform volume, with operating pressures up to 1,500 P.S.I. They are compact in design . . . have few moving parts . . . are low in cost . . . economical in operation. They have built-in suction and pressure check valves . . . ⅜" pipe thread ports . . . and can be used in mineral oil or water. Also, there are similar units available for use in gasoline, kerosene, or equivalent aromatic fluids. Complete engineering data can be obtained on request.

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KINGSTON, NEW YORK

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CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
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VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

Better Designed Products Use Electrol Hydraulics

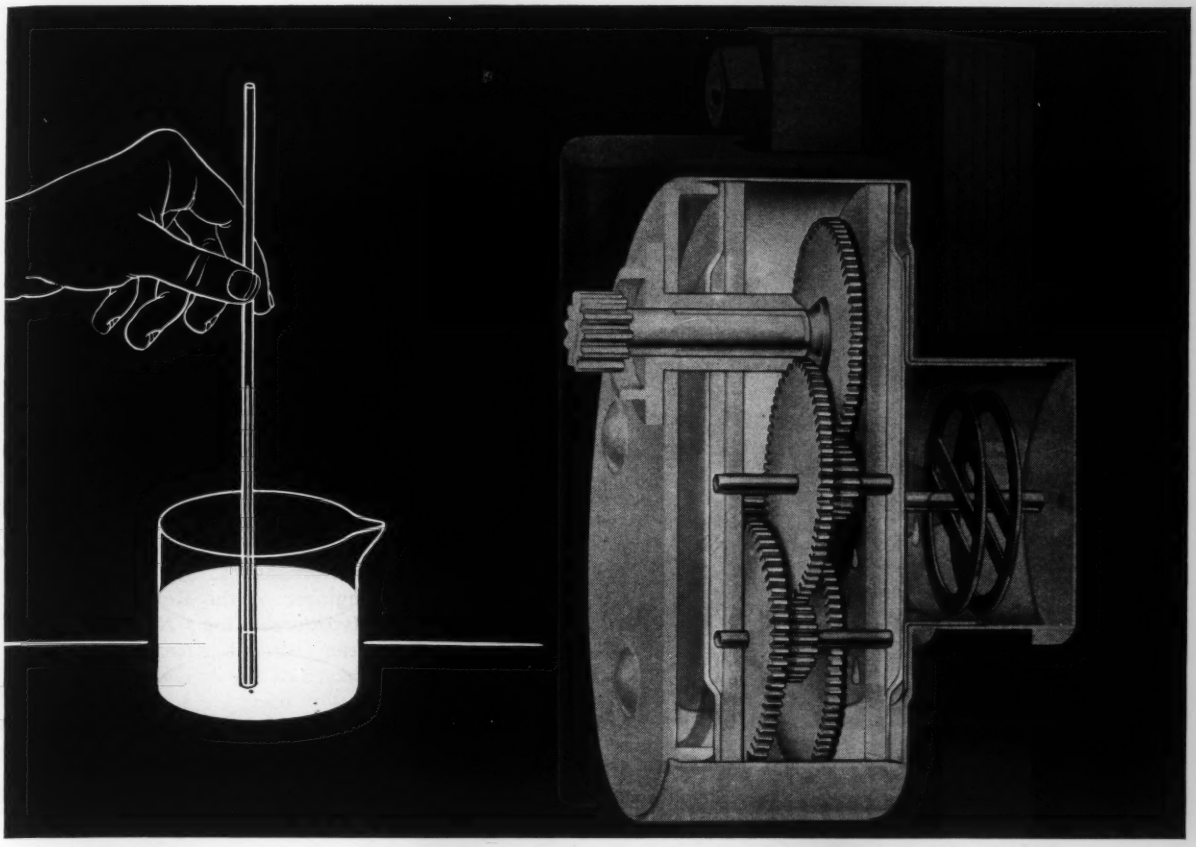
Men of Machines

Inc., Curtiss-Wright Corp. and, most recently, at Chance Vought Aircraft Inc., where he served as chief of missle design. Mr. Palley is credited with the successful direction of the Regulus guided missile program.

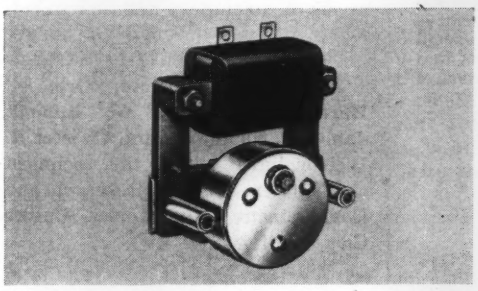
O. H. Yoxsimer has been appointed manager of refrigeration engineering at the new Westinghouse Electric Appliance Div. plant in Columbus, O. He will be responsible for all phases of engineering of both units and cabinets. Mr. Yoxsimer joined the company in 1927 and has worked as a design engineer on refrigeration cabinets, as section manager for refrigeration cabinet engineering and as manager of cabinet engineering at the Appliance Div. headquarters plant in Mansfield, O.

Jacob J. Jaeger

Pratt & Whitney Div. of Niles-Bement-Pond Co., West Hartford, Conn., has announced the appointment of **Jacob J. Jaeger** to the newly created post of chief engineer of the Machinery Engineering Department. Mr. Jaeger graduated from Drexel Institute of Technology in 1933 and received his M.S. degree from Massachusetts Institute of Technology the following year. He began his career as a research assistant for M.I.T. in 1934. In 1940 he became associated with Pratt & Whitney as a



MORE evidence of the extra VALUE in TELECHRON timing motors . . .



Lubrication is only part of the Telechron motor story. Lightweight rotors assure quick starting. Gears are hobbed for quiet operation. Power-line accuracy means true synchronous performance. Separation of the field from the rotor results in cooler operation and longer life.

The accurate, dependable, inexpensive Telechron Synchronous Motor is the heart of timing you see everywhere . . . in clock-radios, washers and dryers; in heating controls, refrigerator defrosters and air conditioners . . . in industrial time switches, recorders and instrumentation.

CAPILLARY ACTION FEEDS OIL TO MOVING PARTS

One secret of the lasting accuracy of a Telechron timing motor is its exclusive sealed-in system of lubrication.

Each Telechron motor carries just the right amount of oil, locked-in against dirt and dust. The oil is drawn up the spaces between bearings and capillary plates by the same free-flowing process that pulls water up the hollow stem of a plant—or a glass tube. Bearings are constantly covered with a thin coating of oil.

This way the oil lasts the life of the motor—which, with a Telechron timing motor, can be for years and years.

Write for complete catalog and full information on our Application Engineering Service. Telechron Department, General Electric Company, 28 Homer Avenue, Ashland, Mass.

Telechron®
MARK OF TIMING LEADERSHIP

Model A 23 Calivolter

CALIDYNE'S NEW CALIVOLTER*

WHAT THE CALIVOLTER IS

The Calivolter is a precise electrical instrument which provides an accurate voltage output over a wide frequency range. True r.m.s. voltages regardless of waveform, and accuracy of ±½% are outstanding features. The Calivolter fills a long recognized need for an extremely accurate but inexpensive voltage standard.

*Trademark

WHAT THE CALIVOLTER DOES

The Calivolter may be used to measure accurately the e.m.f. of voltage-producing vibration, pressure, and seismic pick-ups, as well as strain-measuring devices. It provides a means for accurately calibrating voltage detectors and voltage-sensitive devices such as Vacuum Tube Voltmeters, Oscilloscopes and Sensitive Relays. It may also be used for over-all calibrations of Recording Systems, and for measuring the frequency-response of Amplifiers, Recording Systems, Transformers, High Impedance Meters, etc.

WHAT THE CALIVOLTER OFFERS

Here are some of the advantages and features which you get with the Calivolter:

- *Accuracy ±½% from DC to 10KC — useful to at least 20KC.*
- *Voltage output from 10 microvolts to 10 volts in 5 continuous ranges.*
- *Easy operation, simple standardization.*
- *Low output impedance — max. 1000 ohms.*
- *No current waveform error.*
- *Current output — 1 microamp to 10 ma in decade steps.*
- *A transfer switch and input connection for "unknown" facilitates measurements by substitution.*
- *Small size (8" x 8½" x 4" o.a.)*
- *Lightweight (6¼ lbs.), sturdy construction, matchless quality.*

Write today for specifications and price.

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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Capitol 7-9797
NEW JERSEY
G. C. Engel, Ridgewood 6-7878
PHILADELPHIA, PA.
G. C. Engel, Chestnut Hill 8-0892
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Men of Machines

research engineer and was made assistant manager of machinery engineering in 1951. He is a member of the American Institute of Electrical Engineers and the National Machine Tool Builders' Association.

Waldemar Naujoks has joined Globe Forge Inc., Syracuse, N. Y., as vice president and general manager. He has served as special projects engineer at Ladish Co. for five years and before that was associated with Steel Improvement & Forge Co. for 20 years, 12 years as chief engineer.

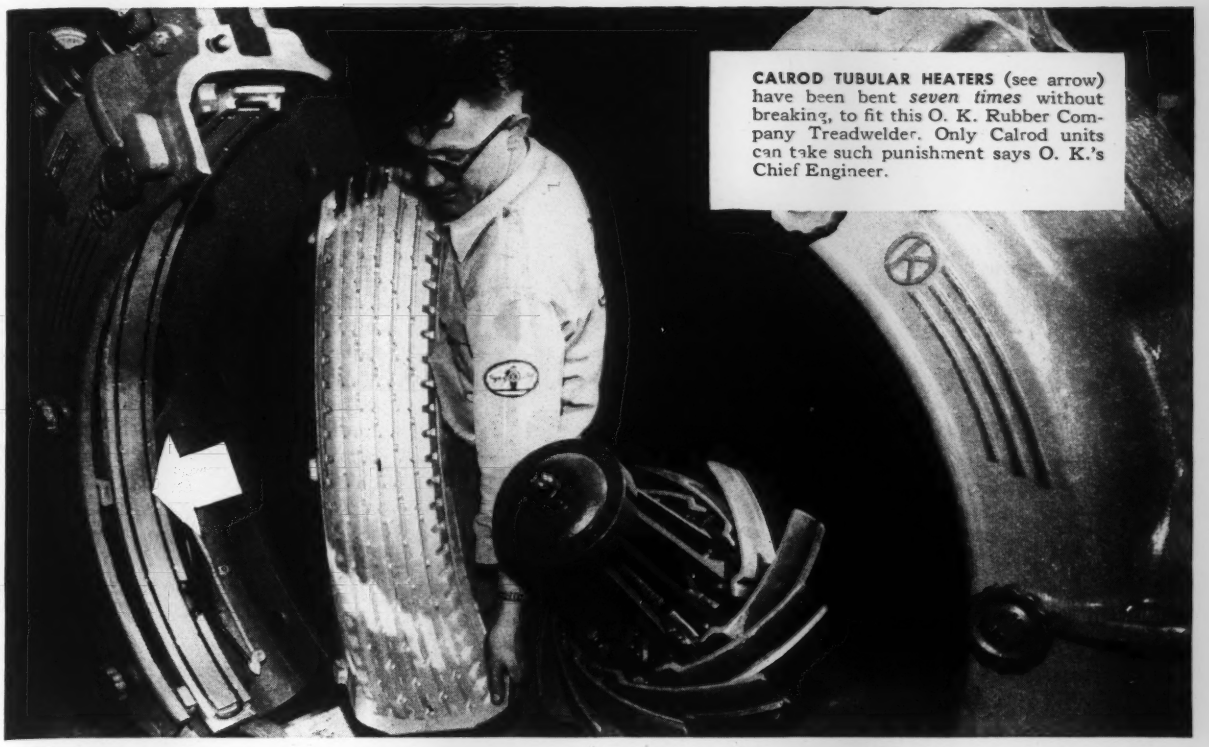
Hermann A. Bottenhorn, chief engineer of the Rolling Mill Div., Hydropress Inc., New York, has been elected vice president in charge of the division.

Formerly design engineer, **Wilder Moffat** has been named projects engineer for Bonney Forge & Tool Works, Allentown, Pa. He will coordinate a program involving manufacturing and quality control, research and development, and analysis of machinery and equipment.

Abraham Glicksman, Orin N. Hertzmann, Frank W. Kohout, James Q. Spaulding and **Chester R. Weislo** have joined the technical staff of the Hughes Research and Development Laboratories, Culver City, Calif.

Edward A. Farwig has been named chief engineer of Buhr Machine Tool Co., Ann Arbor, Mich. Before joining this company, he was assistant to the chief engineer in charge of special machinery design, National Automatic Tool Co., chief machine designer for Pioneer Engineering & Mfg. Co. and chief designer for Premier Engineering Co.

William E. Swensen, assistant chief engineer of Minneapolis Moline Implement Co., Minneapolis, has been appointed design correlator for the company.



CALROD TUBULAR HEATERS (see arrow) have been bent *seven times* without breaking, to fit this O. K. Rubber Company Treadwelder. Only Calrod units can take such punishment says O. K.'s Chief Engineer.

Sturdy, Easily Bent G-E Calrod* Heaters Solve O. K. Rubber's Installation Problem

"We use G-E Calrod tubular heaters because they are rugged, yet easy to bend," says Elby E. French, engineer in charge at the O. K. Rubber Company, Littleton, Colorado.

"We use three of these heaters in our Treadwelder, a machine for recapping truck tires. We have to bend each heater seven times before final installation. Other heaters we've used couldn't take this punishment and had to be sent back to the factory and specially bent. This meant shipping costs and delayed production. Now we bend these Calrod units right in the shop. I know of no other heater that gives the heat we need for our job and still is as easy to bend without danger of breaking."

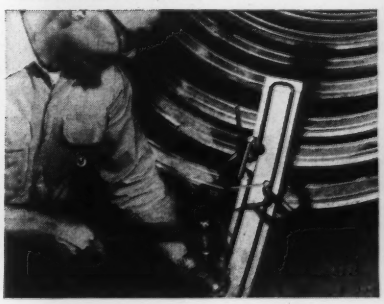
Like O. K. Rubber, solve your design and installation problems with General Electric Calrod heaters. Your nearby G-E Apparatus Sales Office is ready to help you. Call today and write for free bulletin GEC-1005, Calrod Heaters and Heating Devices, Sect. 720-135, General Electric Company, Schenectady 5, N. Y.

*Reg. trade-mark of the General Electric Company.

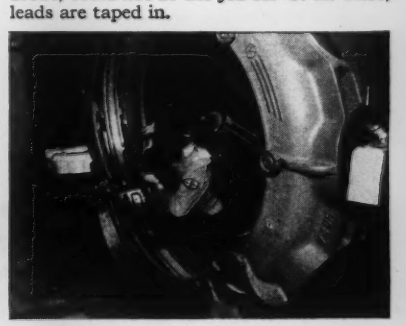
GENERAL ELECTRIC

RUGGED HEATERS ARE EASILY BENT without breaking. Prior to shipment, G.E. anneals heaters in controlled atmosphere furnace to assure safer bending.

HEATERS ARE FITTED to aluminum ring to provide the exact heat required for retreading huge truck tires. Recapping machine is Underwriters' listed.



PRODUCT MADE POSSIBLE because of General Electric Calrod tubular units. Other heaters broke, could not do the job for O. K. Here, leads are taped in.



by Design

BIJUR

AUTOMATICALLY ASSURES CUSTOMER SATISFACTION

the user of your machines

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- Saves on Repair Bills
- Eliminates Costly Hand Oiling
- Reduces Downtime
- Lengthens Machine Life

WITH Bijur Automatic Lubrication as an integral part of your equipment, your customers benefit from continuous peak production. Plant after plant reports increased out-put and greatly reduced maintenance costs with Bijur-equipped machines. Costly downtime for lubricating by hand is eliminated. Every bearing is metered the proper quantity of oil at predetermined intervals. Work spoilage and bearing troubles caused by over-lubrication are avoided. Fire hazards are reduced. Personnel accidents are prevented.

Bijur gives you the opportunity to add customer satisfaction through improved machine performance.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly cooperate in designing a system to meet the specific requirements of your machine.

Design Bijur into your machines now in production or in the planning stage. Write for literature and engineering information.

0-3

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BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

Stress Relief

PROFESSIONAL status versus unionism is a question that is often provocation for into-the-late-hours debate among engineers. Fundamental issues are often discolored by subjective thinking and immediate environment. And it's an argument with perhaps more than two sides.

Not too long ago, speaking to engineering educators, Dean Clement J. Freund of the University of Detroit made some pertinent remarks under the title:

Employers, Ethics and Novice Engineers

A dean of engineering earns his living by doing a number of things. One of these things is to listen patiently and sympathetically whenever an alumnus, especially a recent graduate, feels like weeping on his shoulder.

Not long ago such a one was in my office to tell me his troubles. His troubles were really not very serious. He was two years out of college. He had a good job in one of our Detroit automobile manufacturing corporations. As I remember it, he had something to do with the development and redesign of the combustion area above the pistons. He was making good progress as far as I could see. But he was restless and dissatisfied, and he thought that he ought to resign and look somewhere else.

This interview was a familiar experience. It seems that very many of our engineering graduates are unhappy and discontented.

A Comparison: I could not help comparing this recent graduate with a young physician of my acquaintance who is an interne in a hospital near my home.

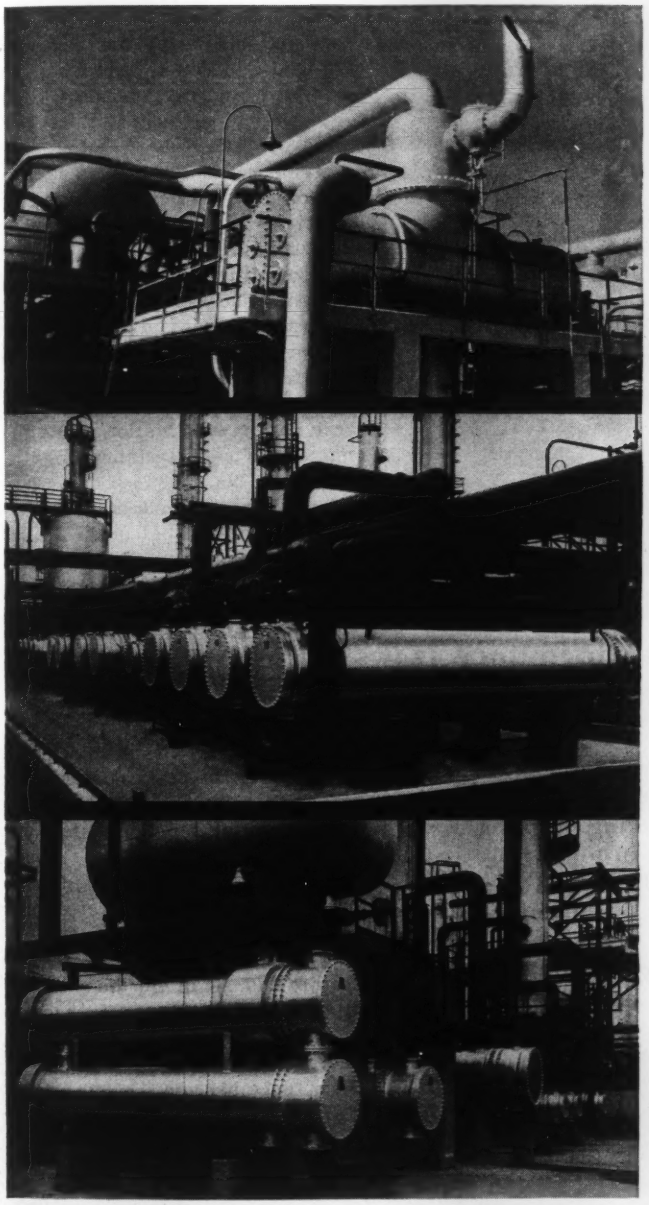
The young physician studied eight years following high school;

this...

ROSS

KEWANEE-ROSS PRODUCTS

on your specially engineered exchanger means BONUS VALUES



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Long a leader in the heat exchanger and surface condenser fields, Kewanee-Ross is today in the best position of its history to meet your requirements. Now, with the added capacity of a second large plant (Kewanee, Ill.), recently re-equipped with completely modern machinery and supervised by key "Ross trained personnel," Kewanee-Ross is ideally situated to supply all types of heat exchangers, built to any code, on a very favorable delivery schedule.

Arrange an immediate consultation with the Kewanee-Ross representative nearest you, at your earliest convenience. You have only your time to invest.

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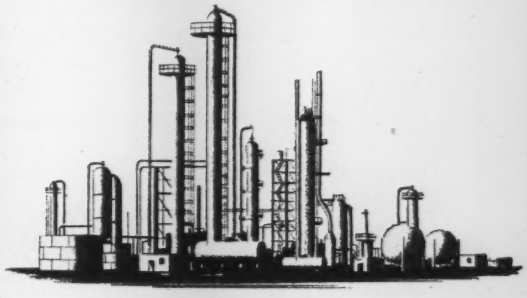

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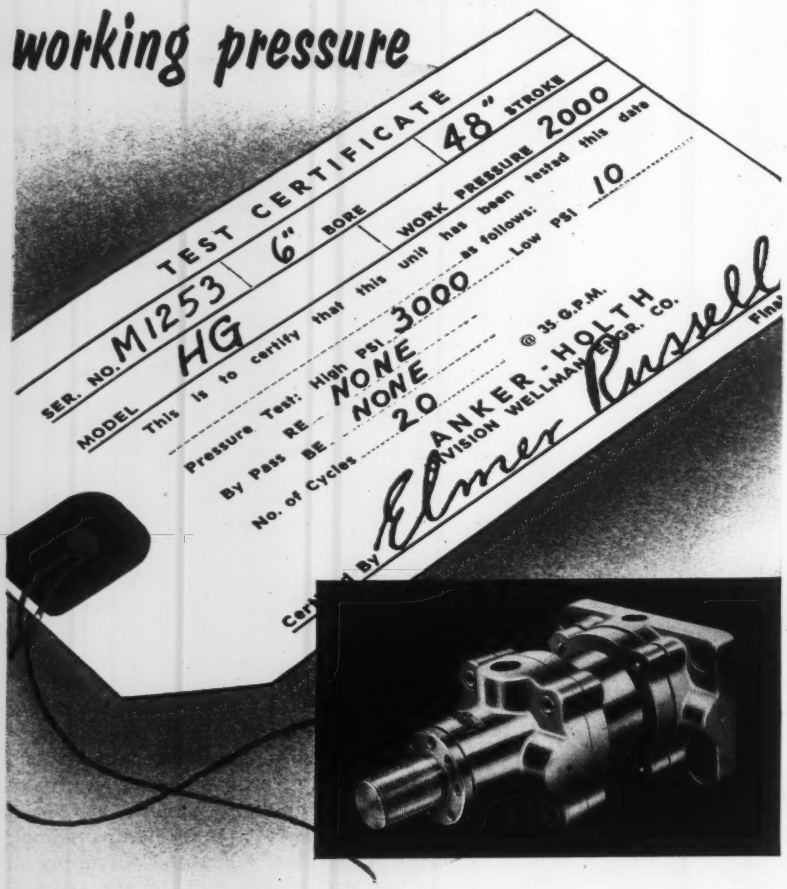

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the young engineer four years. The physician spent about $10,000 in tuition and fees—or his parents did; the engineer about $2500.

The physician has impossible working hours. He is on call day and night; the engineer works an easy 40 hours per week.

The physician is married but lives at the hospital. He gets his meals there although he has an occasional day off. The engineer lives pleasantly with his wife and small son in a five-room apartment.

The physician is paid $1200 per year, and his keep; the engineer was paid $4600 per year when he graduated, and he gets more than that now. The physician is contented with his rugged and meager assignment; the engineer is sitting on top of the world and is dissatisfied.

Obviously, the young interne has something which the engineer does not have. The engineer has an immense advantage over the interne in every respect except for that something. That something makes the young interne happy with his lot, while the engineer is clearly unhappy.

I know both young men very well. I have studied the attitudes and mode of life of each. I have just about made up my mind that I know the secret of the interne's peace of soul.

Professional Standing: The interne is a member of a great profession; he is proud of it and happy about it. The engineer may belong to a profession some day but he is not sure. Certainly he does not think much either of his profession or about it.

The interne is respected. He enjoys all the strictly professional privileges of the oldest surgeon on the staff. He has the title of doctor, and all in the hospital address him as doctor. He has authority over nurses, attendants and other employees, many of them twice his age.

Nobody in the hospital may openly question his medical judgment except senior physicians and surgeons. Patients do not know the difference between him and

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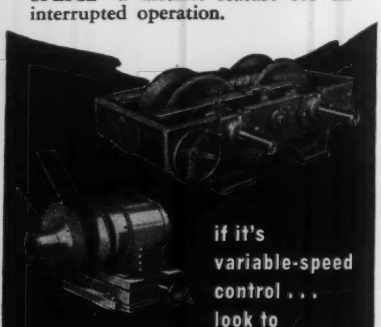

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the younger men on the regular medical staff.

The engineer, on the other hand, is just another employee, no different from thousands of toolmakers, assembly men, payroll clerks, draftsmen and the like. He has authority over nobody. He is a college-trained engineer but, except for personnel officials, nobody knows it and nobody cares.

Significance of Ethics: What has all this to do with engineering ethics? A great deal, it seems to me. Let me start this way. Many employers are worried about unions currently attempting to enroll employed engineers. Several unions have tried, and none have achieved more than an ambitious start. But the succession of failures is small consolation to nervous engineering employers; one might succeed.

This brings us to the core of the whole argument. In my view, employers will have no union trouble if they recognize the professional character of engineers.

Employers, of course, do recognize technical ability and competence in engineering. But technical ability and competence are not the sum total of professional standing. Professional standing is made up of two elements: technical competence and training, and honor and integrity, or ethics.

Engineering employers, it seems to me, ought to be as much concerned about the ethical standards of engineers as they are concerned about technical education and ability.

When I say ethical standards, I mean the ethical codes of the engineering profession. I do not mean the special policies and regulations of the particular corporation in which the engineer is employed. I make this point because employers occasionally call an employee unethical because he has merely violated some special regulation of the individual employer which pertains only to his business.

It would be interesting to inquire of this year's graduating engineering seniors if a single one of them was asked by any inter-

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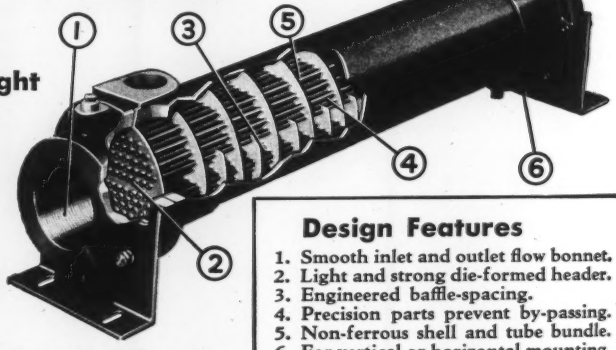

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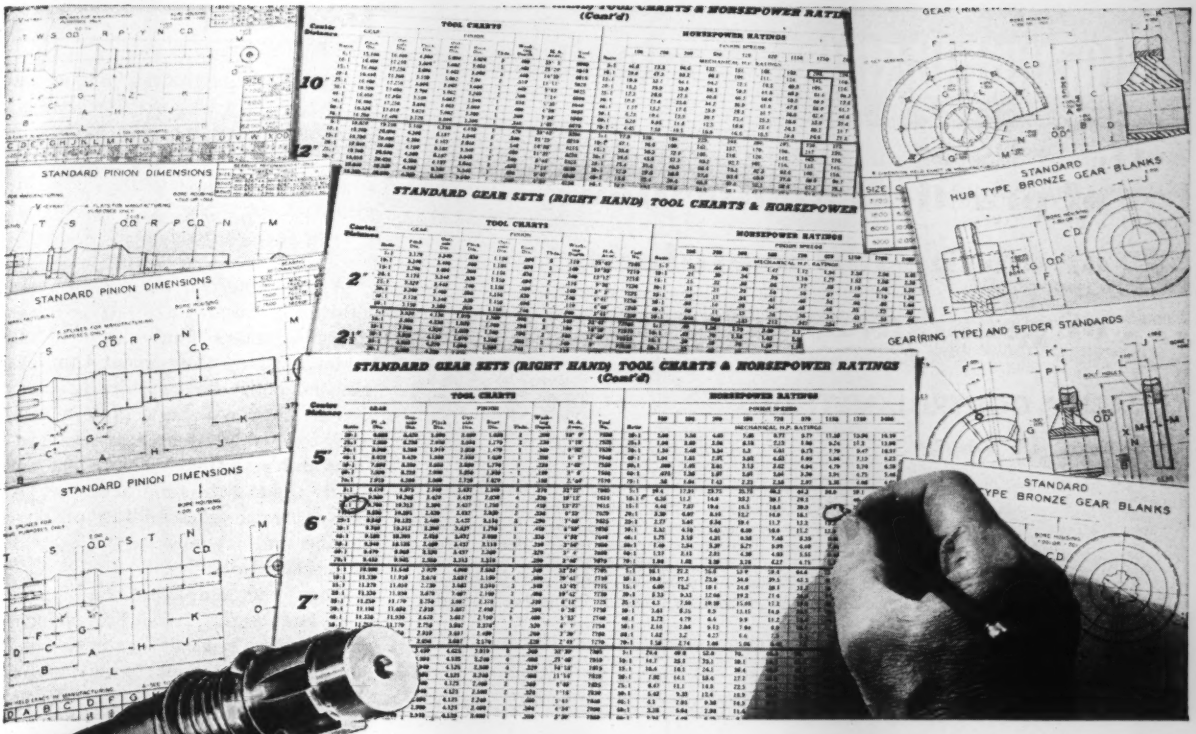

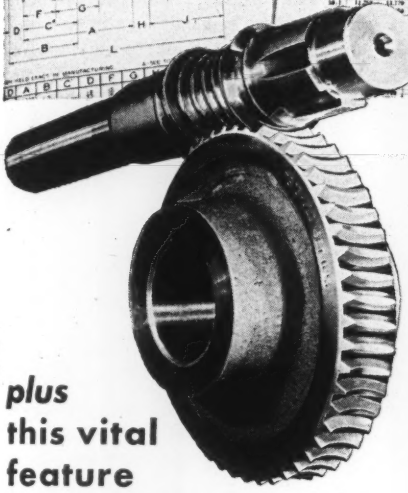

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viewer what he knows about the ECPD code of engineering ethics; or about the code of the American Society of Mechanical Engineers, the American Society of Civil Engineers, etc. Not a single hand will be raised in answer to your question.

When engineering employers habitually and regularly insist that engineers shall know their ethics, just as they insist that engineers shall be technically competent, they will have gone a long way toward giving engineers professional standing. Then, and not until then, will engineers enjoy the professional standing of physicians and lawyers in the employ of corporations.

Once the employer has given his engineers full professional standing, he can safely discard the countless rules and regulations of the familiar employees' handbook, as far as his engineers are concerned. If he explains to his engineers a few basic policies of his corporation, he can thereupon safely depend upon their honor and integrity as professional engineers.

Solution: The employer who does all this need not worry about an engineering union. If he will give to engineers the personal privileges that go with professional status, he will have no union problem in his engineering staff, and few personnel problems of any kind.

No Misunderstanding: It is very easy for me to be misunderstood about an issue like this. It may be important for me to explain at this point, and to explain emphatically, that I am not opposed to labor unions in their proper function, and when they are decently and legally managed. But I am most emphatically opposed to labor unions in medicine, in law, in the ministry and in professional engineering.

"The nice thing about money is that it has such a wide circle of admirers."—CRAWFORD H. GREENEWALT, *president, E. I. du Pont de Nemours & Co.*

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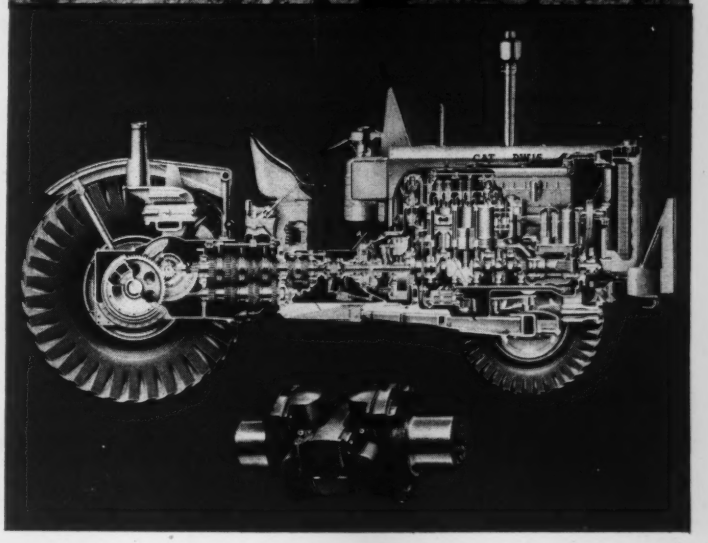
An example of how sales begin on the drawing board is shown by this cut-away view of the Caterpillar DW 15 Tractor. Note that every component in the design is well suited to, and contributes competitive advantages to, the complete product. Among the sales-stimulating features of this tractor is the right type and size MECHANICS universal joints. Here at MECHANICS we work closely with our customers during all phases of their power transmission developments. It will pay you to call in a MECHANICS engineer while your product's power train still is in the drawing board stage—to secure size, weight, service and safety advantages.



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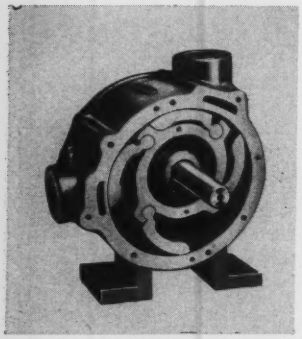
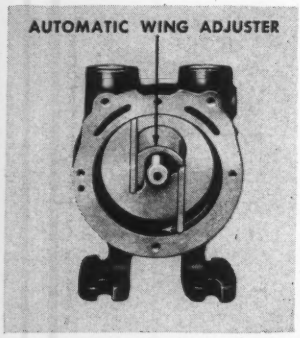


4-WING TYPE

Vacuums to 20"; pressures to 15 lbs.; displacement to 162 cfm. Wings hinged to piston—centrifugal force maintains close, continuous contact to cylinder wall. Wings take up their own wear, insure positive pressure or vacuum. No composition material to require frequent renewal. Air chamber is large because of small piston size, giving unmatched capacity for size and weight of pump.



2-WING TYPE

Vacuums to 29.9"; pressures to 25 lbs.; displacement to 40.8 cfm. Blades cannot stick, because of exclusive Leiman automatic wing adjusting lever which forces each blade to meet cylinder wall, insures positive pressure or vacuum. Only steel blades (no composition) are used. They take up their own wear, deliver years of trouble-free service.

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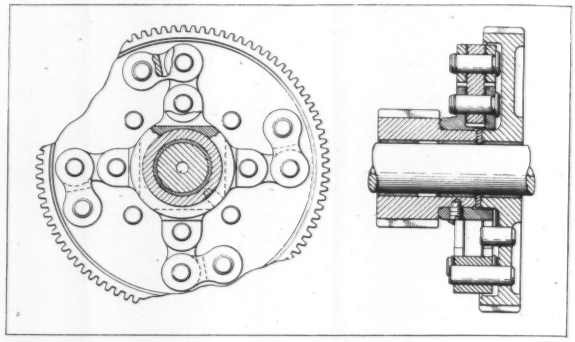
NOTEWORTHY Patents

ARTICULATED SHOCK LINKS absorb torsional vibrations and reduce friction-losses in a novel flexible coupling design detailed in patent 2,653,457. Assigned to General Motors Corp., the coupling employs four sets of linkages, 90 degrees apart, to connect a hub mounted to the drive shaft with a flange on the driven shaft. During rotation, centrifugal force acts upon the masses of the links, establishing the angular relationships of the individual linkages and determining



the amount of torque being instantaneously transmitted. For periods of sudden acceleration, the linkages, in effect, store up energy from the drive shaft and release it slowly to the driven member, acting to retard the acceleration of the driven member and thus minimizing high frequency vibrations. During deceleration, the process operates in reverse. Rigidity of the coupling is a function of the square of the angular velocities of the connected members. Assignors of the patent are inventors R. W. Guernsey and R. C. Ulrey.

REBOUND DAMPING of spring oscillations offers an effective one-way cushioning action for shock and vibration loads and reduces wear in a rotary friction-type shock absorber. Covered in patent 2,653,684, the shock absorber designed by C. Saurer and F. M. Guy utilizes the friction between a disk coated with friction material and an adjustable housing to produce damping action. Shock loads are transmitted to the friction-disk from the operating spring through a linkage construction. In operation, two spring-loaded floating cams carried on the shaft on which the friction-disks are mounted act to provide a one-way "clutching" action, producing damping in only one

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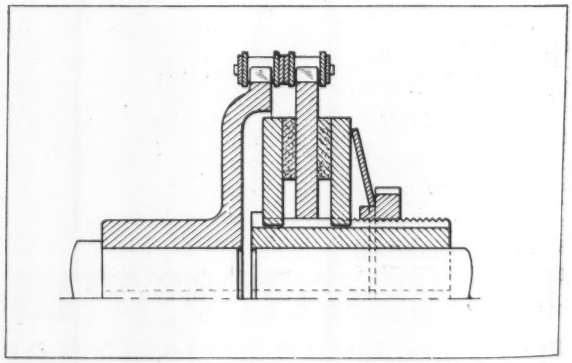
Noteworthy Patents

direction of rotation of the disks. Operation of the shock absorber may be adapted for damping either rebound or impact forces by varying the mounting arrangement. In addition, the construction permits adjustment of the friction surfaces to vary the damping action or compensate for wear. U. S. Universal Joints Co. is the assignee of the patent.

ACCURATE SENSING of differential pressures for measurement and control of fluid flow is achieved with an electric flow meter designed by R. K. MacLea Jr., I. A. Greenwood Jr., and H. Ziebolz. In the design detailed in patent 2,659,390, comparison of fluid pressures in two separate sealed compartments is provided by two interconnected oil-filled bellows, one in each of the compartments. Pressure differences across the bellows produce movements which are translated into electrical signals by means of an arm connected to a moveable transformer core. Zero reference is established by restraining springs in each bellows and a check valve in the interconnecting passage acts to prevent overload. Providing high sensitivity to small magnitude changes, the device is adaptable to automatic temperature control and similar applications. Assigned to General Precision Laboratory Inc., the patent also describes a construction modification for restricted space requirements.

AUTOMATIC TORQUE CONTROL for transmission of power between connected shafts is accomplished with a friction slip clutch design assigned to Morse Chain Co. by R. E. Cherry. Clutching action is provided by two adjustable friction plates mounted on each side of a sprocket wheel free to rotate on the driven shaft. Power transmission between shafts is accomplished through a double-link chain drive driven by a sprocket wheel on the drive shaft. Covered in patent 2,659,220, the clutch can be adjusted to slip at a predetermined load by means of a Belleville spring which controls the engagement of the clutch plates. Various methods of interconnecting parallel shafts for operation under different torque requirements are also shown in the patent.



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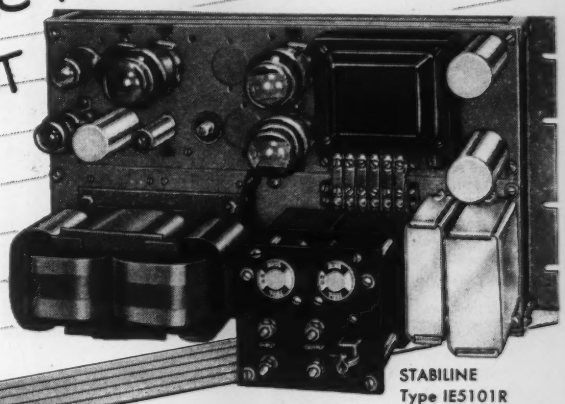

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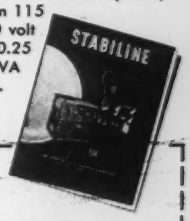

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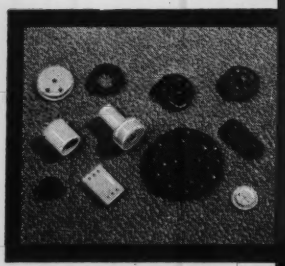

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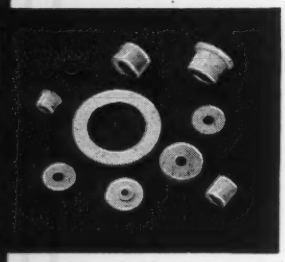
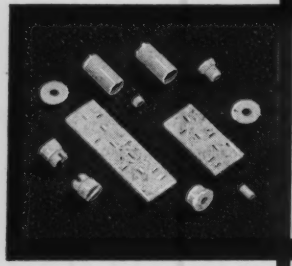
FORMULA 800 PREFORMS — Mansol's newest development — using an Epoxy Resin to improve product efficiency. Possesses extremely high bonding strength, with no shrinkage, on metals to metals and metals to non-metals. Worth looking into! Can save you many man-hours of expensive labor.





STEATITE PREFORMS—We specialize in die pressed ceramics held to the closest tolerances. All tools and dies are made in our own shop to assure quick delivery.

NO DESIGN TOO DIFFICULT—Mansol's engineers are at your service, ready to discuss your powder molding problems, whether they be glass for seals, spacers or lead through bushings.

If you are still making your own preforms, Mansol would like to show you how to save money by eliminating rejects.

FAST DELIVERY

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MANSOL CERAMICS COMPANY
140 LITTLE STREET BELLEVILLE N. J.

CABLE ADDRESS: Mansol—Belleville, New Jersey.

New Machines

Air Conditioning

Electronic Air Cleaner: Compact plug-in unit for average-size homes is slightly larger than a window air conditioner. Current consumption is about the same as a 40-w light bulb. Airborne particles receive a positive electrical charge as they pass through the unit and are attracted and collected on metal plates having a negative charge. Collected dirt is flushed from the plates by means of a built-in water spray system. *Trion Inc., McKees Rocks, Pa.*

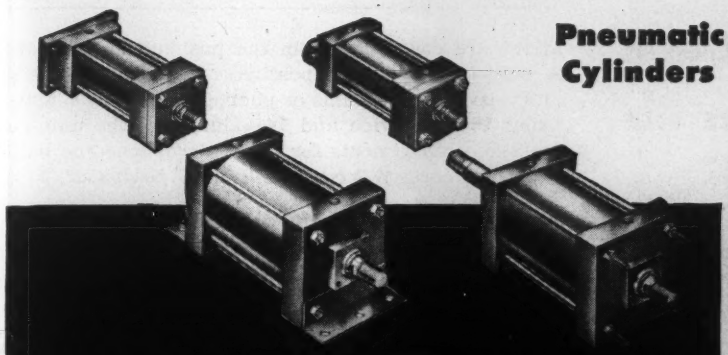
Air Conditioners: Horizontal and vertical style Climate Changers, each made in ten sizes, range in capacity from 600 to 29,000 cfm. Units have sectional casing construction which facilitates installation; all but the largest unit pass through a 36-in. wide opening. Three types of heating coils and five types of cooling coils are available, permitting many combinations for heating, cooling, humidification and dehumidification. Quiet operating fans, having forward-curved blades, are designed for each size unit and operate with approximately 1500 fpm outlet velocity at 500 fpm coil velocity. Units have self-aligning bearings; face and by-pass dampers; water spray, steam pan and steam grid humidifiers; and a mixing box with filter frames, eliminating the need for a separate filter box. *Trane Co., La Crosse, Wis.*

Communication

Magnetic Tape Recorders: Two 35-lb portable models record or play back for 30 minutes; the use of extension reels doubles this time. Model M-30 can be connected to a radio, phonograph or television loudspeaker for amplification; model M-33 has a built-in amplifier. Both units are easily detachable from carrying cases for installation in cabinets. *Magnecord Inc., Chicago, Ill.*

High-Fidelity Phonographs: Four new models have three-speed record changers with balanced turntables, turnover cartridges with separate jeweled long-playing and 78-rpm needles, dual-speaker systems with electronic crossover and three-way automatic shut-off which turns off the changer and the amplifier, returning the tone arm to rest position after the last record has been played. Changer permits intermixing 10 and 12-in. records of the same speed. Available in table and chairside models, as well as portables. *Admiral Corp., Chicago, Ill.*

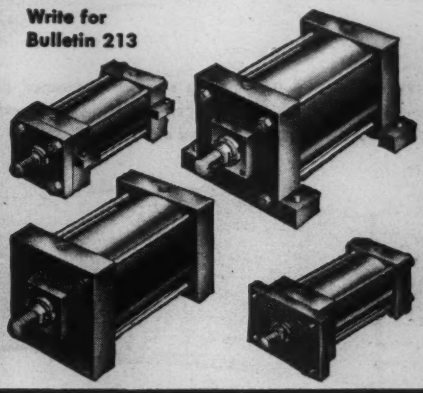
Pushbutton Tape Recorder: Model 4A10 portable magnetic tape recorder has dual speeds and dual tracks. It records at speeds of 3¾ and 7½ in. of tape per second and uses all reels up to 7 in. in diameter, which holds 1250 ft of tape. Maximum recording time is 2 hours. All recording, play-back and winding oper-



Pneumatic Cylinders

Hannifin Series "A" Square Type Pneumatic Cylinders are made in 11 bore sizes from 1½" to 14"...are available with 13 standard mountings, many combination mountings. All tooling is to extremely close tolerances to insure accurate, easy mounting. Cylinders are micro-honed and piston rods are ground and polished. Heavy-duty tie rods. Exclusive bronze cartridge gland is easily removed without dismantling the entire cylinder.

Write for Bulletin 213



NOW...

HANNIFIN HAS THE MOST COMPLETE LINE OF AIR CONTROL EQUIPMENT!

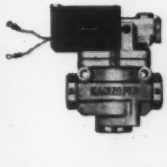
NEW! REVOLUTIONARY HANNIFIN *P-M Pilot-Master Valves*

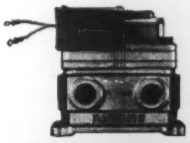
Piston-operated poppet design. Exclusive replaceable cartridge for easier maintenance. Speeds to 600 cycles per minute. Pressure from 15 to 150 p.s.i. Integral, solenoid-controlled pilot heads or a choice of 10 separate pilot valves for remote control.

- Fewer Valves to Stock
- Fewer Parts to Stock
- Maximum Interchangeability
- No Springs in Main Valve

Write for Bulletin 231.

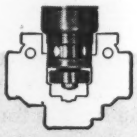
2 and 3-Way Valves.
Same valve operates 2-way or 3-way, normally open or normally closed. ⅜" to 1¼" I.P.S.



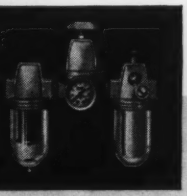


4-Way Valves.
Two 3-way valves mounted in compact, common body. Two piston poppets. Two cartridges. ⅜", ½", ¾" I.P.S.

EXCLUSIVE REPLACEABLE CARTRIDGE



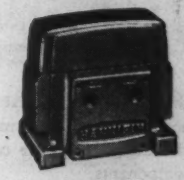
AIR WARDEN
Air filters, pressure regulators and lubricators to protect air operated equipment. Bulletin 1010B.



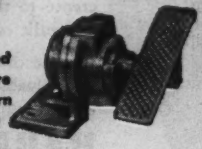
Disc Type Air Control Valves

Designed for smooth, positive and accurate control of air-operated equipment. Bronze discs lapped to perfect seal with seats. Packless design. For hand, foot or electrical operation. Sizes: ⅛" to 1¼" I.P.S.

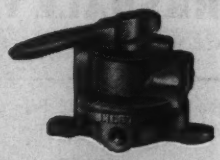
Write for Bulletin 57-W



Hannifin "Directair" electrically controlled air-operated disc valve



Foot-operated treadle valve (Also spring return and rotary types)



Standard hand control valve (Single or duplex)

HANNIFIN

Hannifin Corporation, 1115 S. Kilbourn Ave., Chicago 24, Ill.

Air and Hydraulic Cylinders • Hydraulic Power Units • Pneumatic and Hydraulic Presses • Air Control Valves

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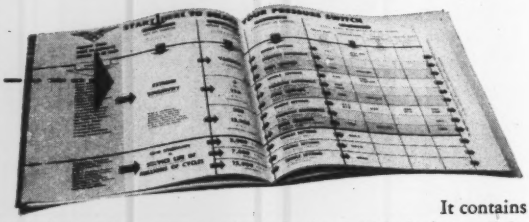
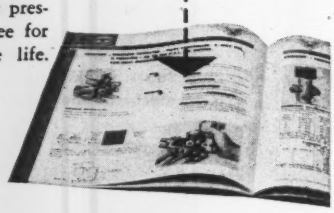
A NEW, COMPLETE REFERENCE FILE OF BARKSDALE HYDRAULIC and PNEUMATIC CONTROLS

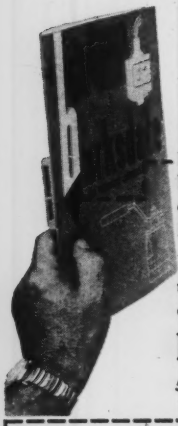
It includes important general information such as a detailed description and illustration of the Shear-Seal principle, the only new valving principle in centuries; covers manual and solenoid valves.



It contains a simplified chart for pressure switch selection, which sheds new light on a subject shrouded in mystery.

It presents the only line of solenoid-pilot valves for air and low pressure liquid with a guarantee for longer solenoid and valve life.





Down to the handy pop-up tab, nothing has been overlooked in providing a more useful reference to the design engineer concerned with hydraulic components.

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ations are controlled from the pushbutton keyboard. A built-in jack makes possible recording from radio and television programs or phonograph records. Measuring 13⅞ in. wide and 14⅛ in. deep, the unit has storage compartments for tape, microphone and built-in ac line cord. *Wilcox-Gay Corp., Brooklyn, N. Y.*

Metalworking

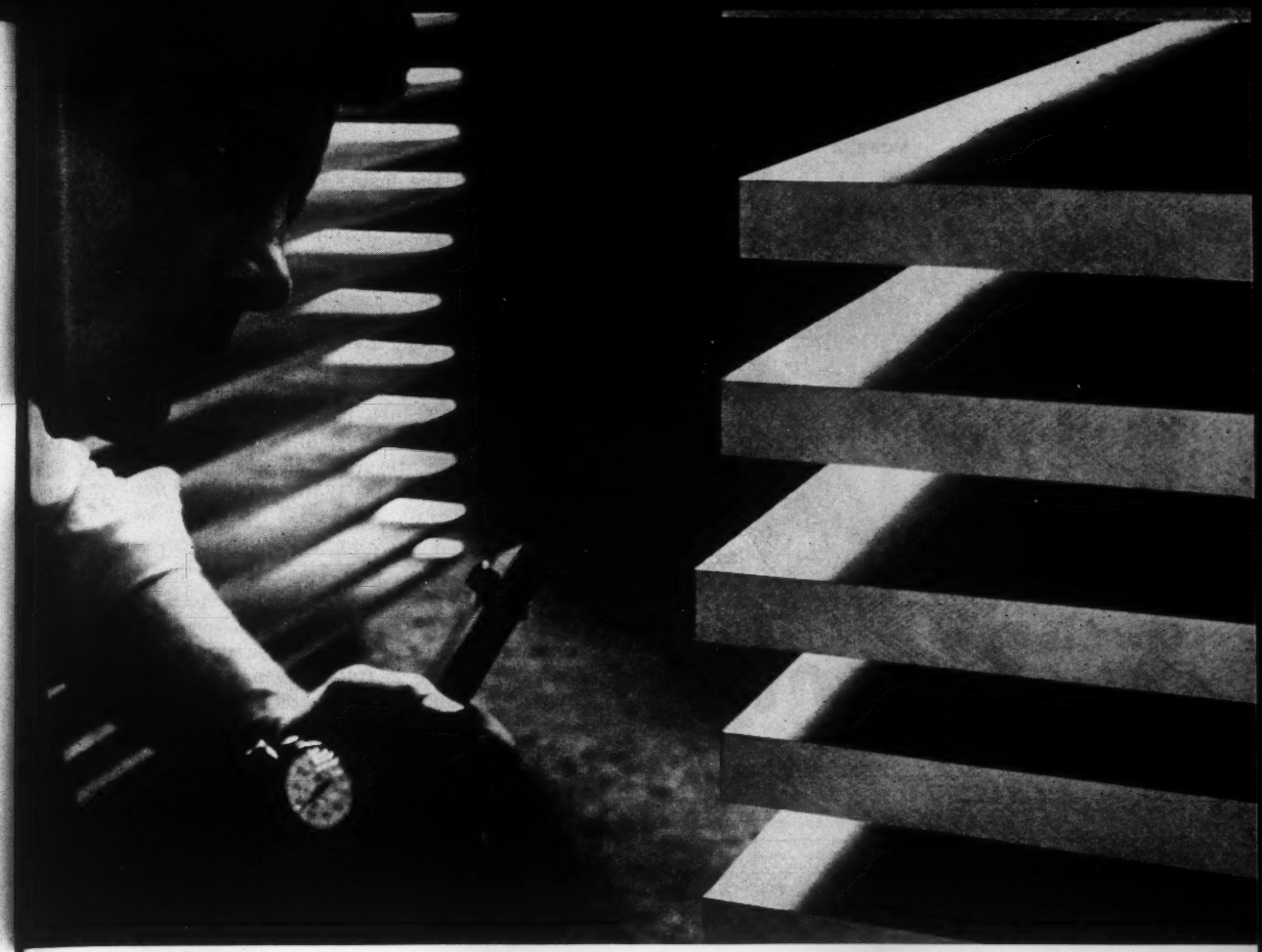
Electromagnetic Punch: Model F Electropunch is suitable for staking, marking, swaging, punching and other high-speed production operations. Open-back, C-frame construction facilitates use with hopper or automatic feed. Solenoid and ram are at a fixed height above the base. Punch delivers uniform impacts, adjustable from a few ounces to 3500 lb at rates up to 125 blows a minute, and can be operated from any 115-v ac outlet. Hand, foot or automatic switching can be employed. Throat depth is 5 in.; shut height, 3¼ in. Unit is 20 in. high, has 9½ x 9-in. base and weighs 50 lb. *Black & Webster Inc., Newton, Mass.*

Radial Drilling Machine: Model E27A Kitchen & Wade radial drilling machine has 36 spindle speeds from 8½ to 800 rpm and nine rates of power feed. Machine can be reversed at any speed. Automatic trip for depth drill covers full feed traverse at one setting. Single lever switch controls both motors through automatic starter. Drive gears are heat-treated nickel chrome steel; drive shafts are high-tensile carbon steel. Machine has 15-in. column and is 5 ft high. *British Industries Corp., New York, N. Y.*

Pneumatic Press: Vi-Speed bench type air press assembles, bends, straightens, punches, stamps, trims, rivets, broaches, crimps and swages. It utilizes air cylinder power units of 50:1 ratio with 1½ and 6-in. stroke, plus an adjustable air stroke limit control. Pressure is adjustable to 2½ tons. Rigidly guided 2-in. nonrotating ram is adjustable by means of ram extensions and will handle off-center work. Work can be placed in machine from all four sides. *Van Products Co., Erie, Pa.*

Hydraulic Straightening Press: Two-way press with two pressure units straightens forgings, castings, extrusions and weldments which must be held down at one point while pressure is applied to another point or which require the application of pressure at two points simultaneously. Two pressure units have both longitudinal and traverse movement, permitting application of spot pressure over almost the entire press bed area. Each pressure unit has a capacity of 400 tons. Bed is 12 ft long and 8 ft wide. Rams have 24-in. stroke. *Hydraulic Press Mfg. Co., Mount Gilead, O.*

Vertical Flash Trimmer: Made in sizes for trimming 4, 7 and 10-in. lengths of work, machine removes flash from inside and outside of thick wall welded rings and cylinders. Capacity is ¼ to ¾ in. thickness and from 6 in. inside to 24 in. outside capacity. Machine is entirely hydraulically operated. Piece to be trimmed is placed over the inner clamp member and ram, and when the cycle is begun by a foot-operated pushbutton, the inner ram member moves forward hydraulically to clamp the cylinder. Both rams



Quality of lightweight magnesium plate is strictly controlled.

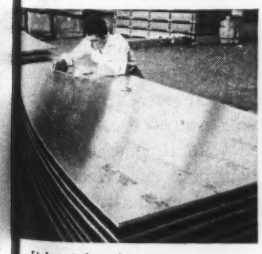
a new look at Magnesium!

PLATE IN LARGE SIZES AT LOW PRICES

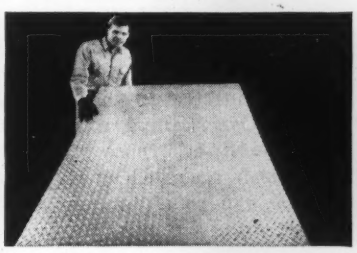
The good news on magnesium plate is Dow's increased capacity—new facilities which are now making longer and wider sizes available at reduced prices.

Also coming in for considerable attention are the important design and fabrication economies made possible by this lightweight metal in large sizes.

For more information on magnesium, call the nearest Dow sales office or write direct to the Magnesium Sales Department of THE DOW CHEMICAL COMPANY, Midland, Michigan.



Lightweight, low cost magnesium tooling plate for more practical jigs and fixtures.



Light, safe, strong, low cost magnesium tread plate in the famous Inland 4-WAY design.

World's first 84-inch magnesium coil mill now rolls sheet and plate to greater lengths and widths.

Lightweight magnesium extrusions are available in many different sizes and shapes.

you can depend on DOW MAGNESIUM

DOW

Now in its 6th year

NOPAK Shelf-Stock Service...

based on these 2 Standard Mounting, Class 1, Cushioned Cylinders

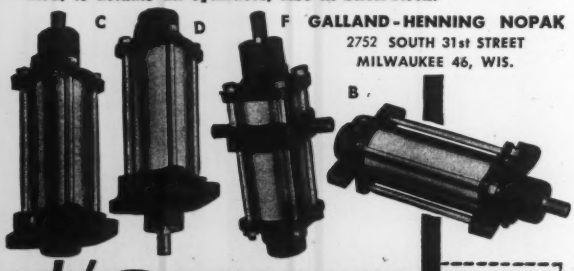
LIST PRICES F.O.B. Milwaukee, Wisconsin

STOCK STROKE LENGTHS — Double Acting Cylinders									
Cyl. Dia. Bore	1"	2"	3"	4"	6"	8"	10"	12"	15"
1½"	24.16	25.72	26.08	26.44	27.16	27.88	28.60	29.32	30.40
2"	26.24	27.88	28.32	28.76	29.64	30.52	31.40	32.28	33.60
2½"	32.36	34.12	34.68	35.24	36.36	37.48	38.60	39.72	41.40
3"	35.04	37.28	37.92	38.56	39.84	41.12	42.40	43.68	45.60
4"	40.84	43.68	44.52	45.36	47.04	48.72	50.40	52.08	54.60
4½"	48.96	51.92	52.88	53.84	55.76	57.68	59.60	61.52	64.40
6"	66.60	70.80	72.20	73.60	76.40	79.20	82.00	84.80	89.00
8"	.....	126.80	129.20	131.60	136.40	141.20	146.00	150.80	158.00

By specifying NOPAK Shelf-stock, you buy quality cylinders at the lowest possible prices, you eliminate waiting for "specials", reduce engineering costs. Compare the prices and scope of NOPAK Shelf-stock (1½ x 1" to 8 x 15") with competitive offerings — and you will specify NOPAK.

● Basic mountings "A" or "E" convertible to "B", "C", "D" or "F", (see below) by changing cylinder heads. Add 10% to above prices, (no extra charge 8" bore). ● Piston Rods NF male thread. ● Cushioning can be eliminated on rod, blank or both ends by removing spring and ball-check.

NOPAK 4-Way Valves, hand, foot, solenoid, or pilot operated, to actuate all cylinders, also in Shelf-stock.



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NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

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A 8003-½

New Machines

automatically cut on the draw-cut downward stroke after which the inside ram and clamp dies move to unclamp position and the rams return automatically to load position. Cutting speed is approximately 6 fpm. *Morton Mfg. Co., Muskegon Heights, Mich.*

Press Brake: Sheet-metal bending brake bends 4-ft wide, 16 gage mild steel over a ½-in. die opening or 2-ft wide, 10 gage material over a 1⅛-in. die. Operating speed is 40 strokes per minute. Back gage, which is operated from the front, permits rapid, accurate resetting. Clearance between side frames is 32 in., maximum die space is 7 in.; stroke is 2 in. with 1½ in. adjustment, resulting in a shut height over die block of 3½ in. *W. Whitney Stueck Inc., Old Saybrook, Conn.*

Threading Lathe: Thread-O-Matic lathe, which can cut a 3-in., 12-pitch thread on 1-in. stock in 36 seconds, has capacity of 18 in. in length and 6 in. in diameter. It cuts internal and external and left and right-hand threads with taper and multiple start. Threading cycle is fully automatic, with the cutting tool completing a number of preset passes at a preset speed and stopping automatically at the end of each cycle. Maximum working speed is 2000 rpm, and cutting rate can be more than 100 cuts per minute. *S & S Machinery Co., Brooklyn, N. Y.*

Portable Pneumatic Nibbler: Having an extended head which permits its use in confined areas and in formed metal panels, new nibbler cuts sheet metal up to 18 gage and can cut a radius as small as 1 in. Cutting can be started anywhere an access hole is provided, and the nibbler can follow any contour. It is available with lever or lock button throttle. *Buckeye Tools Corp., Dayton, O.*

Metal Saws: Line of 16-in. band machines has 12-in. thickness capacity. A heavy trunnion and cradle support the 24 x 24-in. work table. Table tilts 45 deg to the right and 10 deg to left. Machines are equipped with standard saw guides which can be interchanged with six other types for specialized sawing. Models are available with fixed or variable-speed controls with speed range between 50 and 5200 fpm. Attachments and accessories are available to adapt machines for such purposes as band filing, metal polishing and carbide finishing. *DoAll Co., Des Plaines, Ill.*

Slitting Line: Equipment including an uncoiler, slitter, coil and sheet feed tables, recoiler and coil stripper accommodates 48-in. wide material at normal production speed of 158 fpm. Slitter arbors are driven through universal joints from a spreader type gear box connected to the motor mounted on the slitter base. Overrunning roller clutches mounted on each of the slitter arbors provide free wheeling when the slitter is operated as a "pull-through" type. Recoiler drum can be either manually or hydraulically operated. *Kane & Roach Inc., Syracuse, N. Y.*

Portable Hand Tools

Grinder: Series 9 Handgrinder can be used to clean casting and weld seams and to polish and grind heavy

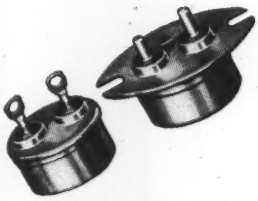
Here's How to Solve Your Temperature Control Problems . . .

USE STANDARD

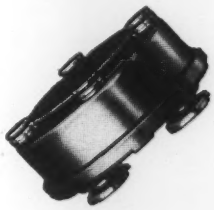
KLIXON

Thermo Snap®

CONTROLS

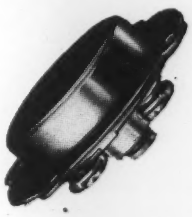


C4344
Hermetically Sealed



C4320
Exposed Disc

C4391
Hermetically Sealed



C4370
Enclosed Disc

A-1" and SA-½" Series

C4371
Immersion Type

Designers and manufacturers seeking accuracy and efficiency in temperature control rely more and more on *standard* Klixon Thermo-Snap Controls.

Actuated by the Spencer snap-action thermostatic disc, they snap open with a quick clean break . . . close to a solid make . . . always provide accurate control in every application whether it be in civilian or military products. Small and compact, they fit into products without complicated design or alterations. And because you can usually use *standard* Klixon Thermo-Snap Controls to do the job, you save money by eliminating special thermostat design.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges. Write for complete information, today.

KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
2508 FOREST STREET, ATTLEBORO, MASS.

and irregular work. Chuck has ¼-in. capacity. Grinder is powered by ¼-hp continuous-duty universal motor which develops 15,500 rpm. Built with rifle type handle, grinder weighs less than 7 lb. *Dumore Co., Racine, Wis.*

Short Drill: Measuring slightly over 12 in. in length, new electrical drill has back-spade type handle which can be removed for even shorter chuck line length. Pipe handle is also removable. Key type chuck has chuck key receptacle in handle for easy accessibility. Model 123 has ½-in. capacity in steel, 1⅜ in. in wood. Chuck speed with no load is 550 rpm; with full load, 330 rpm. No. 383 has ⅜-in. capacity in steel, 1⅛-in. in wood and chuck speed of 800 rpm with no load, 580 rpm with full load. Both drills may be obtained in voltages of 115, 125, 150, 230 or 250. *Stanley Electric Tools, New Britain, Conn.*

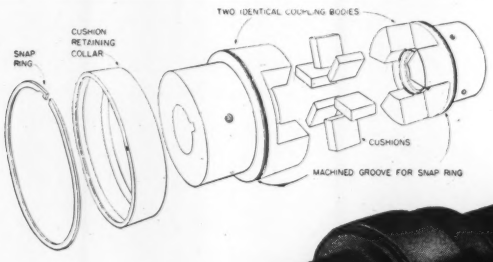
Testing and Inspection

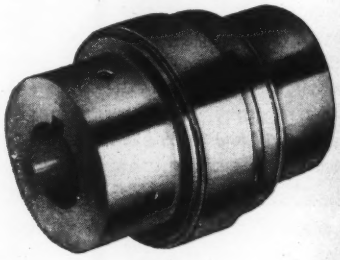
Optical Bench Comparator: Instrument is designed for fast comparison of precision parts against master charts. Illumination from below 6 x 10-in. comparator stage provides accessibility to the work area. Focusing is accomplished with a single adjustment knob. Part under inspection is shown in bright silhouette on 10-in. diameter, wide-angle screen which can be viewed by several persons at once. Selection from five different projection lenses provides magnifications of 10x to 50x. Lenses are easily interchangeable. Comparator measures 21 x 15 x 23 in. and weighs 110 lb. *Bausch & Lomb Optical Co., Rochester, N. Y.*

Shock Tester: Jolta guillotine type bench model tester is designed for testing relays, electric meters and other electrical and electronic devices. Calibrated for direct readings in accordance with most military and commercial specifications, it accommodates specimens measuring up to 5 x 5 x 5 in. and weighing up to 4 lb. Mechanisms can be tested while in actual operation and under electrical load. *Jan Hardware Mfg. Co. Inc., Brooklyn, N. Y.*

Contour Projector: Model 30 projector, with 30-in. viewing screen, permits inspection of complete parts or portions of very large parts. It provides choice of either shadow or surface illumination and can be operated in ordinary room light. Instant changes in magnification are made without refocusing, and unvarying 8-in. distance is maintained between the lens and the plane of the object under inspection. Other characteristics include a staging area with a 17-in. throat; 8-in. horizontal and vertical table travel; a built-in helix table with worktable rotation of 15 deg off center in either direction for setting helix angles; horizontal and vertical micrometers accurate to 0.00005-in. over their entire 1-in. range; direct-reading screen for angular measurements which can be read without vernier from a precision engraved dial calibrated to 2 minutes of arc; and a built-in 1500-w light source for surface inspection with Kodak normal surface illuminator. Six interchangeable lenses are available, ranging from 10x to 100x magnification. *Eastman Kodak Co., Rochester, N. Y.*

LOVEJOY FLEXIBLE COUPLINGS





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• Lovejoy's simple, rugged design permits easy, quick installation or removal. Load cushions are in plain sight at all times for rapid inspection and can be removed without tearing down the coupling.

• One-half the cushions act as idlers during operation, except on reversing loads. In non-reversing operation, the cushions can be reversed to double their service life.

• Lovejoy Couplings *never* require lubrication.

• Lovejoy manufactures a complete range of flexible couplings from fractional to over 800 hp. Get full information on this "maintenance-free" line, including catalog with complete specifications and operating capacities.

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